Tectonophysics

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R. C. Searle (Harins Physical Laboratory of the
Society Institutions of Commongraphy, Le Jolie, OA
920931, R. M. May
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A Climate Hypothesis Describing the Solar-Terrestrial System as a Frequency Domain With Specific Response Characteristics

Douglas A. Paine Biometeorology Unit Cornell University Ithaca, New York

The evidence for and against sub-r variability influenting weather and climate is lieset by conflicing results (e.g., see Colciberg, 1982). This ande will examine a new point of departure that is designed to complement shaple cause-and-effect methodologies. The study is laused spon an analogue to contemporary quantum

Individual atoms are known to exhibit thiscrete absorption and emission responses to incoming radiation. John Jacob Balmer's 1885 description of the visible lines in the livdrogen spectrum was soon extended by Lyman and Humphreys to include both the ulnaviolet and infrared components defining the simplest atomic element. In the late 1970's I decided to test a climate concept based upon the known variability of incoming UV radiation and outgoing infrared that also displays a similar discrete frequency response. This response is primarily controlled by the triatomic molecules of O3, H2O, and CO2 that exist as diabatically important trace gases within earth's armosphere.

The experiment produced its own notable success in predicting the 1981-1982 winter temperature departures evaluated by a power spectral technique [Paine, 1982]. These results were promptly followed by a spectacular failure this past winter when errors of up to 16 T between the observed and the expected departures were registered over the Midwest.

The elapsed time between these two results gave ample opportunity for speculating unon ally the complexity of climate might be well saited to the worldview aftered by quantum theory. Both the success and the failure bous on the postulated importance of significant changes of atomspheric stability by diabatic processes that is in keeping with the coupliasis provided by Max Planck in 1900. Specifically. Planck had the insight to avoid a detailed dexaption of the diverse phenomena associatd sub electromagnetic physics. He strove in-lead for a single mathematical statement that add describe how a simple harmonic oscilhor was excited or clamped by changes in the stability of its surrounding environment. Indoing so, he accomplished a unifying radiation law that was able in accommodate not taly long (e.g., infrared) and short wavelengths (cosmic through X rays), but ultravio-let frequencies that appear to trigger impor-un changes in both the biological and die dinate domains.

# Tropospheric-Stratospheric Stability

Our discussion begins with the documentation of stability changes linked to the onset of a major drought. I have always been curious about a discrepancy that first came to my attention in the mid-1960's: namely, preparation of temperature-height profiles for the U.S. Extension to the ICAO Standard Atmophere (Figure 1) revealed some significant lifferences between data gathered in 1054 ersus that compiled in 1962. The 1954 ounding profile came during a sunspot mini mum, and it depicted an isothermal lapse rate above the tropopause boundary to near 25 km; the 1962 profile slinwed a more conhoed isothermal lapse rate (10-20 km), while a modest thermal inversion was found in the 20- to 30-km layer. Rocketsondes confirmed that a strong inversion from 10 mbar (30 km) to 1 mbar (48 km) reflected maximal diabatic that increased toward the stratopause bound-

Such a discrepancy might have easily passed unnoticed, except that much of the Nonheast experienced its worst drought of record from 1960-1966. Namias [1966] had thown that the driest period, as depicted in Figure 26, was paralleled by abnormally cold Ontinental shelfwater from 1963-1966. He med this annmaly to argue effectively that he chilling of the lower tropospheric column ould be expected to enhance the static stabil-

Douglas A. Paine is an Associate Professor of Biouniversity's Cornell University's College of Ag-iculture and Life Sciences, Ithaca, New York. He holds an M.S. in melearol-ogy from the Pennylymorion from the Pennsylvania ile University and a Ph.D. in atmospheric sci-cutes from the State University of New York at Albany. His research and leaching interests span the prediction of severe local storms to mechanisms of climate change, including the inecital in the change. the possible influence of climate stress upon evolu-

ity and thus decrease the vigor of precipita-tion events over the northeastern United

The 1962 temperature-height diagnosis of detectably greater stratospheric stability, commencing near 20 km, suggested that a kind of resonance in enhanced stability in both the lower tropospheric and the stratospheric regimes may have contributed to the drought situation. Was it, therefore, only coincidental that the name stable profile in 1962 came only 4 years after the strongest sunspot maximum of record (200 sunspots), as munimed during the International Geophysical Year

Likewise, the recent 1980-1982 composite of accumulated precipitation departures shown in Figure 26, with its notable delicits to the lee of the Appalachian Mountains, follows closely after the second strongest (yearly) sunspot maximum of record. The excessive incoming ultraviolet, peaking near December 1979 as shown in Figure 3, would be expected to enhance the diabatic release of heat (142 ] mol-1 °K-1) associated with ozone production in the middle to upper stratosphere. The consequent downward diffusion of this hear could have conceivably strengthened the positive lower stratospheric lapse rate mult 1987. (The forward phase shift in the 'solarinduced stable mode shown in Figure 3 represems an idealized schematic. It is meant to account for the glapsed time of 2 or 3 years that would be required before the diffusion process significantly reduces the depth of the sothermal lapse rate.)

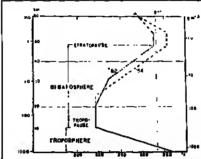


Fig. 1. Temperature height mobiles to 60 km for the U.S. Standard Atmosphere depicting the 1954 versus 1962 observed differences in stratospheric lanse rates above 20 km.

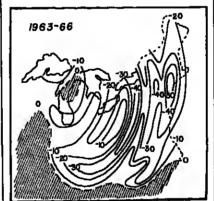


Fig. 2a. Observed 1963-1966 cumula tive precipitation deficits. Isopleth interval equals 10 Inches (254 mm). Maximum 1960-1962 consulative deficits of 20 inches were confined to a narrow corridor extending from Concord, N.H., to Bridge-



Fig. 2b. Observed 1980-1982 curiulative precipitation departures relative to 30-year mean. Isopleths labeled in inches; dashed lines and shading represent excesses, solid lines designate deficits. Sources include 1980—1981 Local Climato logical Data (National Climate Center) and 1982 (preliminary data) published in the Weekly Weather and Crop Bulletin (NOAA/USDA Joint Agricultural Weather Encility).

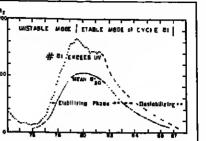


Fig. 3. Solar cycle 24 compared to mean of cycles 8-20. Mean monthly sun spot values (R2) from Sular-Geordiysical Data, U.S. Department of Commerce, Builder, Colo. Date marks indicate June of each year; cycle 21 hegan June 1976. and is projected to end June 1987.

However, the April 1982 eruption of El Chichon added additional complexity to the situation. The volcanic debris' abserved reinforcement of lower stratospheric warming coming in phase with the quasi-biennial oscillation (QBO) may have been strong enough to override the expected trend in the East toward enhanced stability well allove the tropopause. Parket and Brownscombe [1983] reput ted a +tek t+8ort warming at 30 mbar over equatorial latitudes, a situation that actually may have reversed the expected positive tem-perature gradient above 24 km. Either way. the phasing of the positive temperature trend induced by QBO-El Chichon working in conson to after the lower stranospheric stability. or the coupled role of enhanced stability in-Terred from 1960 to 1966, directs our attention to the manner in which diverse energy sources are able to reinforce or to cancel one

### On the Importance of Resonance

At the end of the severely cold 1976-1978 wimers, my interest in the physics of climate grew when a Cornell colleague showed me a eries of ourses like that depicted in Figure 4 As New York's chinatologist, Boyd Pack had been ploning the 20-year running averages of winter seasonal temperatures, milizing data estending back to 1892. These curves indicated that the recent perind over the interior Northeast has been cooler than any previous decade in the 20th century.

A careful inspection of the December-February running averages revealed a notable acceleration of longterm warming (1923, 1933) and delay in time-averaged cooling [1954, 1965, 1976) near the onsecol live out of seven surspot minima (1). Two questions came to mind as I studied these curves: (1) What could give the temperature graph the appearance of the output generated by a thermal ca-pacitor that slowly 'discharges' to reflect diminished heat input during one phase (maximum to minimum) of the solar cycle? (2) What rould then cause this same thermal capacitor to 're-charge' vigorously (or entrain heat) beginning around surspot minima? The answers might involve the tendeocy for cold air masses spilling southeastward from Canada to extract considerable latent and sensible heat from the Great Lakes or the nearby warm waters of the Gulf Stream. If so, then the geographical dimensions of these heat storage areas would present the potential for resonant interactivity between solar, atmospheric, and even hydrospheric energy

From the quantum viewpoint, we can en-Lakes exhibit natural harmonics in relationship to the 11.2-year periodicity of the sunspot cycle, just as this cycle is Itself a harmon-Ic of the 90-year Gleissberg cycle [Agee, 1980]. The large-amplitude patterning of the pre-elpitation deficits shown in Figure 2a—looking very much like a 'standing-wave' config-oration excited over and amplifying to the lee

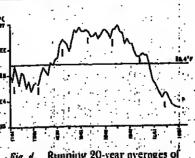


Fig. 4. Running 20-year overnges of winter season (Dec.-Feb.) temperatures (F) in the Finger Lakes region of central New York. Length of data record: 1802-1985. Arrows indicate timing of observed sunspot ministra.

of the Great Lakes-suggests this simplifying concept is applicable to the physics of climate. Nested primitive equation modeling of classic lake-effect snowstorms by using moisi diabatic physics [Kaplan and Paine, 1973] had earlier revealed an overlooked subtlety in the dyoamics of vigorous air-sea exchange: that is, not only does it require relatively cold flow down the length of the longest lake letch, but the miggering atmospheric wave generates the largest response when the dimensions of the energy source or heat reservoir represent some harmonic of this wavelength.

### Climate Complexity and the Laplace Transform

Just prior to the unprecedented 1978-1979

winter with its severely cold departures across the entire contiguous United States (Diaz. 1980], Figure 5 was constructed from the observed cooling pattern exhibited since 1950. and was recently applated and extended to the expected timing of the next sunspot mini-mum in 1987. The mathematical formalism used to generate and interpret this curve is based upon a systematic and elegant proce-dure widely used in the study of feedback and control. The complexity of climate built upon forcing functions ranging over a vast variety of time scales seems particularly suited to diviount of analysis because it requires knowing only the governing periodicities and response amplitudes characteristic of the dynamical system. (The 11.2- and 90-year sonsporycles, plus the commonly observed range of winter averages in the Northeast spanning ±7°F (7°C)—or 0.5°F on the 20-year running average scale-set the necessary parameters in Figure 5.) In dis treatment, one iv asked to imagine a valuaterrestrial birchi composed of diabatic energy capacitors, mchiclory, and resistors that are combined man one reaches a desired outcome replicating the behavior of the physical system at hand. The reader is referred to the appendix of Sokolin koff and Redheffer [1966] for a more detailed

The top right-hand corner of Figure 5 depicts the resultant Laplace transform of an 11.2-year periodicity drawn over three solar cycles, after first neglecting the superposed buggerin periodicity from 1954–1987. The curve at the bottom of Figure 5 shows how the minima of observed Zurich sunspot num bers for cycles 18-21 captures the ensemble effect of enhanced heat entrainment commencing with 1954, 1965, 1976, and 1987. The latter year is the projected timing of the next sunspot minintum as documented in

Figure 3 and Lincoln [1970]. The value in formulating this background trace is that ic provides a quantitative point of reference for 'reading' either gradual depar-tures from the idealized trace—like the recent flattening of the projected cooling trend io the 1980's-or the sharp departure associated with the 1982-1983 wioter. In the former case, the particularly unsteady profile prior to 1920, and the flattened peak associated with the relatively warm winters in the 1940's, indicates that greater heat exchange fluctuations may prevail near the long-term winter temperature extrema. The recent 1982-1983 winter anomaly may therefore represent a return to a similar period of greater year-tovear uncertainty about seasonal departures. It is also interesting to speculate whether the 1983–1984 value for the 20-year running av-

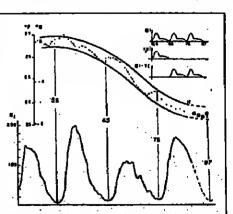


Fig. 5. Observed and projected 20-year running averages, (°F, °C) for winter season in central New York. Upper righthand inset depicts Laplace functions (see appendix) ht to tise I I-year sumspot cycle. years of minima as indicated. Zurich sunspot numbers (R,) plotted at lower portion of diagram illustrate the observed (and 1987 projected) reversal in the long-term cooling trend at souspot minima. Warm anomaly (cross) registered in 1982-1983 wimer yielded a +10°F error in expected seasonal average based upon solar UV modulation (i.e., 29.4°F observed versus 19°F projected). :

erage will return toward the previous extrapolated value or remain near the new plateau

established by last winter's anomaly. A 'elimate circuit' designed around the Laplace technique can easily include either a periotlic QBO effect or a single-incident component like that of a strong volcanic event. Furthermore, the inferred alteration of stratospheric stability by El Chichón's sull'uric acid haze larer emphasizes the important role of anomalous albedo duration at any atmospherie level. For instance, the record length of somewover throughout the Northeast in the 1977-1978 winters [sec Dewey and Heim, Jr., 1982] had earlier suggested the need but adding an 'enhanced alhedo' component to the mathematical circuit to account for lower tropospheric rhilling. This cooling dropped the observed winter averages 2°F below the expected solar-induced departure, while the absence of an effective sunwcover albeilo this past winter may have contributed up to onethird of the +6°F departure (relative to the 30-yr mean observed over western New

### **Direct Versus Indirect** Solar Signals

Currie [1979] published evidence of a solar signal in surface air temperature over Notth America utilizing the maximum entropy method (MEM) of spectral analysis. The largest amplitude of the observed 10.7-pear signal (0.9°C) was found over the Northeast. The depressed thermal peaks near the time of sunspot maxima led many investigators to postulate a direct sunspot-climate link; that is, the dark undra/penuadira distinguishing simpletts have long been thought to reduce the net sular output by a few tenths of 1% [see Huyt, 1979].

The indirect mechanism of altraviolet control over diabatic heating of the troposphere by inordulation of anajor storininess—enlanced I rom sunspot minimum-to-maximuru-which is postulated here does share one thing in common with Carrie's result. The inferred sunspot signals in both studies weakened toward the far South and were effertively absent to the west of the Continental Divide, to fact, this investigator found substantial differences in the 20-year running av crage curves across the 600-km length of New York state, seemingly dependent upon the proximity of the five regional profiles javeraging 12 stations per sector) to lakes Erie and Ontario. These differences appear to argoe in favor of the importance of in situ dia-batic heat sources in generating the idealized (indirect) 11-year signal, while latinulinal or continental dependency (direct solar heating and bulk heat transport) would help to shape such long-term references as the 90-year wipter means of 25.4°F versus 18.7°F in central New York and the St. Lawrence Valley Region, respectively.

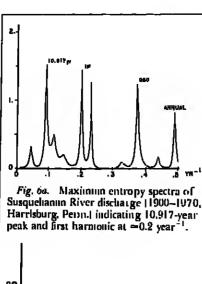
More recently, an 11-year thermal signal has been confirmed over northern Europe yet is notably absent over central Asia [see Kerr, 1982). These equally meaningful null results obtained over certain portions of the globe, and not others, may be tied together by a common dynamical thread. For instance, the lack of a detectable 11-year signal on this continent occurs next to the cold upwelling of Pacific water along the West Coast. In rentral Asia, or Canada's Hudson Bay region, warm surface waters are essentially unavailable for heat transfer in winter because of their outright geographical absence or substantial snow and ice cover. I refer to such regions as 'diabatically dormant' portions of the globe, just as other areas and atmospheric levels are

In the case of the far South Ibelow 35°N the cold air intrusions over the warm Golf of Mexico are more sporadic from winter-towinter than at the latitude of the Great Lakes (40°-45°N). The southern intrusions often produce the most effective atmospheric heat realization when latent heating is maximized farther north over the eastern United States, a process that requires major macrocyclogenesis and its embedded vigorous convection to reach peak efficiency.

### Role of Intense Convection in Coupled Dynamical Studies

Before attempting to relate how UV modu-lation of stratospheric stability might help to account for a solar-induced thermal signal, I feel it is important to explore the possibility that the hydrological cycle and the observed discharge of a major northeastern river may be linked to the t1-year cycle. This will lend added credibility to the postulated importance of latent heat release, since only convective storms can approach the 100% efficient conversion of water vapor into condensate, In contrast, macroscole uplift in witter cyclones absent convection is only about one tenth as efficient in precipitation production. We will also want to document that triggered convective activity in both the atmospheric and the continental shelfwater regimes has a crucial self-regulating role to play in mulntaining the vigor of biospheric activity.

Figure 6a depicts the result of applying MEM to the 1900-1970 lime series of the river discharge observed at Harrisburg, Penntyl-



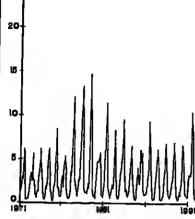


Fig. 6b. Predicted mean monthly discharge (1971-1991) in ft<sup>3</sup> s<sup>-1</sup>. Both figures adapted with permission from May

vania, centered within the Susquehanna watershed. This 27,500 nui2 drainage basin luis only limited man-made modification above Harrisburg, and ranks as the Inrgest such basin in the Eastern United States. The Susquehanna River is situated midway between the eastern Great Lakes and the mean location of the Gulf of Mexico stormtrack that runs between the Gulf Stream and the Appalachians. May [1981] found a 10.917-year periodicity and its first harmonic, as well as a possible reflection of the QBO. The same technique applied to the mean yearly sunspot number (1900–1970) revealed a 10.549-year power spectral peak, including its two harmonics at 5.280 and 3.495 vears.

A prediction model described in May's M.S. thesis is an autoregressive or feedback system where 300 coefficient involve one-half the data length. The 195ti-1970 test prediction from the 1900-1950 cinic series showed that individual 'flood' or 'drought' years were not necessarily captored by MEM; however, the 5-year composite of the integrated discharge was more skillfully represented. As a recent eaample, the 1971-1991 prediction shown in Figure 6b missed the eacessive precipitation year of 1972 which included Hurricane Agnes and runoff from heavy winter snows ger erated by a major Nor'easter, but the outlook captured some of the record wetness in the late 1970's followed by the very dry beginning to the 1980's. Embedded in this predicted period is the

so-called New Jersey anoxia (oxygen-depletion) incident involving large kills of shellfish in the New York Bight region during the summer of 1976. This is the same year a sim ilar anoxic condition of El Niño last occurred off Peru, prior to its 1982-1983 return that covered a record eight million square miles of the equatorial Pacific, (Although the 1975-1976 winter was also labeled of 'anonialous character over North America, the first 2 months of that winter were distinguished by sharp cold over the East, as opposed to the record warmth that began the 1982-1983 winter. The detailed comparison between these two winters suggests care must always be exercised when assessing die relationship between + 10°F departures over the northcentral United States and unusually warm Painc water in the tropics. For instance, repeated cold outflows from Siberia maintained an unusually large and intense Alcutlan low over the Gulf of Alaska, representing a very efficient sensible and latent heat pump near 60°N latitude [see Wiin-Nielsen, 1982]. However, it is true that the more modest 1975-1976 El Niño was marked by +4° to +6°F de-

partures over the Northern Plains, In assessing possible authropogenic (toxic waste dumpingl versus environmental factors that may have contributed to the 1976 oaygen-depletiun incident, I will quote from a summary by Alooeis [1978]. It began by relating shelfwater biological activity to horizontal kinetic energy profiles examined along the eastern seaboard. Both zooplankton and phytoplankton, plus fish, are associated with spectral density peaks in the frequency distribution that describes barotropic and baroclinic ('storm') disturbonces in this domain, as well as onnual, diurnal, and intertidal cycles. Mooers continues:

After a severely cold December and January, there was an early spring: Atmoss spheric warming produced thermal itratlication plus stownelt and river tyroff and hipselfinity and applied density

stratification alumt a mouth earlier than normal. An intense and persistent ldmm of Cerotium tropus in the region may have been 'supported' by this intense clensity stratification; its eventual decomposition could be expected to contribute to lal ceduction of the dissolved oxygen contentration in the lower layer. [Upper and lower layers are with respect to the thermodine, while 'supported' is a double rutendre: (1) The strong density stratification physically supported the Cemtinu; (2) it provided a physical niche they could exploit and monopolize to mitcompete other phytoplanktion hir light and outrients. The anomalously early stratification olivirusly climinated ventilation of the lower layer by free convection. As sociated with the early atmospheric warming was an early cessation of the wintertime weather cycle of vigurous cole fronts and cyclones. This could be expected to reduce the amount of forced convection produced by wind stirring of the upper layer. Other factors came into play with a shift of the weather cycle. In early summer, a several-week period of weak but persistent wintle with a poleward component occurred idl New Jersey, driving coastal apwelling. Associated with the upwelling was an nitwelling (toishore flow of lower layer water of nutrient-rich and oaygenated water from the outer to the inner shelf. During this period, the dissolved oxygen concentration in the lower layer decreased at an anomalous high rate and reached a level much lower than the usual late-summer mini-

Of special interest are the inferred roles of 'free' versus 'forced' convection in this incident. In the ocean, free convection is overturning due to negative buoyancy induced by cooling or evaporation at the sea surface. Forced convection refers to mechanical stirring due to wind-generated waves and turbulence in the upper layer, or tidal motion stirring the bottom layer. Helping to resulve the anoaia condition in late summer was Hurricane Belle which passed over the region as a small, swiftly moving, spiral-banded convec-tive system with 93 mph squalls. Again, quoting from Mooers: 'This hurricane generated vigorous inertial oscillations and some wind stirring, but it did not overturn the water culumn . . . the stratification quickly "healed," leaving the ventilation of the lower layer to the normal automnal cooling."

Students of meteorology sometimes create an effective analogue to atmospheric convertion in fluid tanks by injecting a 'milky' sidine solution from a syringe into clear water, then videotaping the event with a camera mounted upsidedown. By scale similitude of the Froude number-or the ratio of the kinetic to potential energy characterizing a turbulent event-the final inverted image of the saline plume looks a great deal like the mining of cloudy and clear air surrounding positive buoyoncy accompanying a cumulanimbus. (A I°C temperature excess in the cloud yields a buoyancy factor of  $5 \times 10^{-3}$  which can be asily matched by the saline mixture to give identical Froude numbers of  $2 \times 10^{-2}$ ) 11 the vertical mixing of life-supporting mutients and oxygen is aided by storm-generated convection, is there a similar mechanism that might explain how macroscale cyclogenesis with its vigarous embedded convection is aided and abetted by solar modulation of incom-

### Solar-Terrestrial Connection

ing ultraviolet radiation?

Major storms with central pressures of less than 1000 mbar (100 kPa) are invariably accompanied by a break in the tropopause boundary which serves to separate the stratuspheric and tropospheric regimes. (The neight of the troposphere, globally averaging between 10 and 16 km, has been observed to oscillate by 0.5 km with an 11-year periodicity over the equatorial Pacific, peaking near sun-[1981] was limited to data obtained from two radiosonde stations, the time series itself being restricted to two solar cycles. It would be interesting to perform a spectral analysis of the varying thermocline depth—the ocean's analogue to the tropopause-provided a

more suitable time series was available. A tropopause break and its attendant fron-tal discontinuity (thermal inversion) enrich the troposphere with storm-producing cyclonic spin by creating the downward transport of stratospheric alr. Such air is characterized by large magnitudes of positive poten-tial vorticity or potential cyclonic spin once the atmospheric column in question is destabilized by diabatic healing at its base, Storms of this intensity are also found to enhance the planetory boundary layer's upward flux of sensible and latent heat by 1-2 orders of magnitude. The sunspot component of the quantuni climate hypothesis effectively asks whether or not such incidents of tropopause folding and breaking are somehow augmented when a lessening of the incoming UV radiation results in significant episodes of lower auralospheric destabilization.

Unlike the positive buoyancy excited by the Input of diabatic hear at the base of a tropospherio column, these openions of strato-

spheric instability would most likely be a tached to incidents of negative buoyang air that descends because it is colder that surrounding environment. The farther scent of negatively buoyant air would on when the Ox-diabatic heat source and now quent downward dillusion of heat had dir ished, effectively replacing the modes in sion from 20 to 30 km shown in Figure I

with an isothermal lapse rate below 27 to Such episcules of intense subsidence dis guished by their descent of large position nes of potential voticity, are mon likely at triggered by the momentum deposition; ing from vertically propagating intend gravity waves. These acoustically modified waves aften originate in the tropospher wherever strongly sheared flow is found crussing touchilating terrain Hones and Houghton, 1971], as well as arising near the stream core within so-called "jet streaks"; ducing wave-induced | Kelvin-Helmholt

The capability of vertically propagating waves to juriduce narrow zones of money turn deposition wherever the wave traces buity encounters a background flow of a magnitude is usually met at the level of the sharp transition in the lower stratosphere lapse rates. The numeritum surges crea this level of deposition are capable of displ ing relatively cold layers which then over warmer air, commencing the descent of the denser valuate with its large potential tone ty toward the tropopause. This investigate has found that the above sequence of esem typically precedes tropopause rupture by 6-12 hours [Paine and Kaplan, 1974].

The critical climate control of more freent cyclogenesis in the troposphere cod therefore be exerted by simply providing through UV modulation a deeper isother lapse rate in the lower stratosphere. (The B Chichou-QBO destabilization of this same zone is likewise postulated to have overwhelmed the current solar-induced tende toward stabilization, perhaps even creating volumes with an uncharacteristic temperat decrease with height near 25 km to promo even upire frequent macrocyclogenesis. Equally vigorous packets of upward-propgating, internal gravity waves could only duce negatively buoyant plumes capable of reaching the tropopause houndary in theu of an isothermal for even less stable] envir mem prevailing from 20 to 27 km. A mode inversion dominating at these leres would mitigate against high potential vorticity po from ever reaching the troposphere lath regard, it would be interesting to compare mean stratuspheric lapse rates prevail thuring the very dry 1980-1981 cpisode is affected unich of the contiguous United States, versus the more recent excessioly se

period (1982-1983). Normally, additional UV radiation accompanying strong storspot maxima would be pected to maintain a modest inversion from 20 to 30 km, as in 1962. This stable node hyputhesized to lead to a decrease in the number of exchanges across the trupopaus boundary of downward floring high por tial vorticity pands, with a consequent of crease all air-sea interactivity tied to less fre quent and intense major storm develops over which water source regions. Seen in the way, the sudden reversal in the cooling in frequenting sunspot minima, os shownin fi ures 4 and 5, represents a type of dynamic discharge that hegius to release an increase; mumber of patential cyclonic spin "pates" (negatively buoyant plumes) built up durist the stabilizing phase of the II-year solar o-

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Analogue to Planck's

The extreme sensitivity of trapospheric cr dogenesis to the depth of the stratospheric thermal layer becomes come confermandable when we consider that potential vorticity ally increases from 2001 to 20,000 units 1x10-10 cm s oK -1) between the height of the repopalise boundary to 30 km. Thus, the illerence of only a few kilometers in the added height of this layer can easily make available a substantial increase in the positive otential vorticity inherent in the negatively

Enels [1942] potential vorticity theorem aposed of a synthesis of the conservation laws for mass, momentum, and energy in a ngle mathematical statement—has received side application in diverse dynamical studies anging from oceanographic to ionospheric. for our purposes, where we are attempting to synthesize into a single mathematical statemen the exchange of information among many dynamical regimes, it is instructive to consider that potential vorticity is closely aligned to the concept of angular momentuen. Each volley of apward-propagating or temal gravity waves that serves to disludge a y baoyant plance of high potential orticity is thus creating a discrete "packer" of donic angular momentum capable of sig-

ificantly influencing tropospheric dynamics. This unifying concept brings us full circle, back to Planck's discovery of the quantum nature of radiation and Schrödinger's wave equation that describes the exchange of angula momentum among complex systems. As was mentioned in the introduction, Planck began his derivation with an equation descriptive of a simple harmonic oscillator. Although the oscillating element was originally conceived of as an electron embedded in an electromagnetic held, contemporary physicists emphasize that different sets of elemenary particles represent varying "resonance channels" or patterns of quantum connec-

Not only is this mathematical formal appealing when it comes to describing the com-

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Cover. Auroral imagery from the DAISP-FB satellite. The two photographs are from the DMSP Optical Linescan System, taken on consecutive northern benti sphere polar passes on January 18, 1983. The dawn aurora is in the lower part of the photos, with midnight to the left and dusk at the top. The overlayed contours show bremsstrahlung X ray intensity measured by the scanning SSB/A X ray senso Provided by The Aerospace Corporation's Space Sciences Laboratories. (See Ess, p. 170, May 3, 1983.) (Photo courtesy, D. J. Corney D. D. Miller and W. A. Kolar. Corney, P. F. Mizera, and W. A. Kola-

plexity of the solar-binspheric-climate gestalt, but even the interim idea put forth by Bohr that an atom consists of discrete energy levels scents relevant to the highly interactive atmospheric and oceanographic domains. However, what constitutes an "electron" in the pres-

If we recall that "sunsputs" consist of intense convective disturbances in the solar atmosphere, then the obiquitous nature of convective processes in all dynamical domains reminds us that they alone can rhange the identity of a system at its most fundamental level. The aunospheric analogue for an equation describing a simple harmonic oscillator:

$$\ddot{\tau} + \frac{f(S)}{\rho G_0} \dot{\tau} + \frac{g}{T_0} |\gamma_d - \gamma| \, \tau = 0 \quad [1]$$

states that the zeroth, first, and second-order time derivatives of T-or the temperature difference realized in a convective event which is 100% efficient in creating condensare—furms the mathematical basis for describing superefficient information exchange within atmospheric dynamics. In addition to the diabatic or quantum signal represented by \u03c4, other variables in \u00e41) include the density and temperature [p. T.], the gravitational acceleration (g), the dry adiabatic and environmental lapse rates (ya, y), and the specific heat at constant pressure  $|C_p|$ . The term f(S) refers to the position of the buoyant parcel relative to its initial entropy state, where the parcel's change of entropy is dependent upon its change of

potential temperature, and Cp. If the coefficient of \u03c4 is negative, then the buoyant parcel will be dislodged from its original constant entropy level; if positive (stable case), the parcel will oscillate about its original position at a frequency giren by

 $v = [(g/T_c) | \gamma_d - \gamma]^{1/2} / 2\pi$ 

Like Blanck, we use a change of emropy plus specific frequencies to define information exchange among macroquantum domains. We thus avoid a spatial description of the livdrothermodynamic field by simply noting how an elemental oscillator (convective event) heliaves when embedded in a held characterized by a particular stability. This annums to saying that the convective event is a discrete element of radiative thix which obeys Stelan-Boltzman's law for a blackbody [see Panic and Pensinger, 1979].

We have been addressing the negatively buopant, stratospheric phenomena in much of the above discussion. Let us now shift our attention toward the equally important, positively huoyant [tropospheric] events that accompany the macroquantum information exchange process. The atmospheric analogue to Planck's law descriptive of the energy (U) of the radiant fields states

$$U = \frac{h^* v}{e^{h^* v^* C_P T} - 1}$$

This analogue substitutes  $C_n$  for k (Boltzman's constant), while the tropospheric value for Planck's constant (h\*) has empirically been found to equal 21 × 1010 erg s. [The energy (E) which may be dislodged from a discrete layer whose putential is defined by h\* is determined by a specific frequency of oscillation (v).) In a severe convective storm generating internal gravity waves, a typical ratio for the eapment  $(h^2\nu/C_pT)$  is 0.025, where the scale height of the troposphere (10 km) must be eacecded by the upward propagating waves to achieve information transfer. This height is effectively compared against the horizonta distance (400 km) of a "bowed" frontal inversion. Such a density discontinuity or interface serves as a wave guide for external gravity (or so-called "shallow-water") waves organizing coherent bands of severe convective activity.

The advantage of employing quantum physics to explain highly nonlinear, multiscaled information eachange between complea systems is its elegant simplicity: for example, satellite pictures may present a bewildering view of warm water eddies breaking away from the Guif Stream or developing cunulonimbi in a thunderstorm ensemble that defy a detailed Newtonlan-Cartesian solution. Yet the quantum approach tells us that the energy entering or leaving a limited domain must appear at a specified frequency for its harmonics) uniquely determined by  $\gamma$ ,  $\gamma_d$ , p, and  $T_s$  if there is to be a fundamental change in the system's identity. The quantum view of climate supports the

concept first entertained in the content of the Laplace formalism: namely, warm water bodes function like "tuning forks" and thus are able to act as a colierent wave and energy source for the atmospheric medium, provided the appropriate multilevel stability criteria. are met and the proper "hammer" is present. The 11.2-year sunspot cycle is apparently one such instrument where the interactivity with earth's heat reservoirs (including the O<sub>3</sub> layer) occasionally rings loud and clear in the physics of climate. Other possibillities come to mind; for example, the highly variable ener-gy inputs associated with solar flares of cosmic ray emissions; all have the potential of exciting resonant states of activity at decipherable levels of the atmosphere when

viewed from the quantum paradigm.

Alternatively, El Chichon in the quantum world view appears much like a high ener-

gy" dimate evera whose rare has alle of roteinning interactivity may have had the ability in dramatically aliet one or more of the momal pathways that constitute the rich matrix of solar-terresicial connectivity. After a short review of the posmilated role of solar-modulated incoming UV radiation, we will address the question of mankind's ability to alter earth's climate via the absorption of untgoing infrared radiation by increased amounts of carbon dioxide. Once again, the quantum climare hypothesis is found to affer new insight for scientists seeking to gauge the influence of the ungoing exponential rise in the burning of lossil linels on the effects of changing earth's albedo through the melting of sea ire or deforestation.

### Conclusions: Factoring in the Influence of Mankind

A simple cause and effect concept of climate has assumed that the greater the solar input, the more heat will be available to the atmosphere. This is correct, provided one is careful to distinguish the particular level that s heated and also its ultimate effect. Because phraviolet radiation represents only 14% of the net solar energy received by earth, most of which is absurbed above 10 km, its primary importance is one of controlling strato spheric stability. When there is greater ining UV radiation, the enhanced production of azone provides an important diabatic heat source to the stratosphere. This added stability, in turn, could conceivably suppress the number and intensity of major tropo-spheric sorms unless overridden by other

Such storm suppression would effectively decrease the upward flow of sensible and latent licat into the lower atmosphere. Paradoxirally, we therefore see that the net effecof greater UV radiation—beating only a small, but dynamically important portion of the middle attrosphere—is therebye to chill the weather-producing triposphere. (Alternatively, prolonged absence of sinispors, such as in the 17th century's Manuder Minimum or the earlier Sporer Minimum, coubl effectively exhaust many of the hear reservoirs by coninhuting to greater climate instability and storminess. Presumably such a dynamical sequence, as evaluated in occambed and ice cores, would lirst provide a "rush" of diabatic heat input into the troposphere, followed by longer episodes of abnormal chilling t The nonlinearity of the postulated triggering mechanism enables the slow buildup of stored solar energy arising from the net incoming radiation to he released over relativeg short periods of time. This, in turn, yields a commensurately greater response factor to the physics of climate. From a biological perspective, large short-term thermal fluctuations can also extract a severe evolutionary toll, as evident from the reported loss of an estimated 17 million seabirds on Christmas

The self-organizing and self-regulating capacity of the oceans, atmosphere, and biophere working in consort to maintain earth's life support system is receiving increasing attention. In keeping with James Lovelock's (besis examined in *Goio [Larclack, 1979*], I have chosen the interdisciplinary concern over COs lankling to illustrate further how quantium climate idoysics accenticates the critrial toles being played by trace gases like Oxand CO2. Ozone is subject to chended sources and sinks (e.g., NO<sub>c</sub>) that are (lean-selves subject to (audilication by anthropogenic activity; however, for brevity, the CO2 problem—although far from keing "simple because it, too, changes in proportion to the varying backdrop of bioxidictic activity, occasi temperature, and circulation—will suffice to demonstrace adother potential application of the quantum paradigm.

In prior discussion, we have stressed stability variations associated with the diabatic effects of water vapor, a rather "profilic" trace gas that constitutes anywhere from the 41% of the troposidere by total volume. From 1958 to 1980, atmospheric carbon dioxide content has risen from 315 to 338 parts per million [MacCracken and Mosec, 1982], and increase of 8% in 22 years. The corrent scienrific consensus estimates that CO<sub>2</sub> may have increased by 25% since 1850 and is likely to double its 0.034% vulume content before A.D. 2100. Additional CO<sub>2</sub> at the projected level of increase has the capacity to absorb greater amounts of the returning longwave radiation, creating the so-called "drafty" for correctively influenced) greenhouse effect. Essentially linear nordels of climate have extrapolated that at least a 2°C global warming and oursequent melting of polar sea ire and rise at sea level could result from this effect within the next century.

However, the quantum climate hypothesis shilts our attention away from any linear or direct climate influence by asking a two-part question: First, how is mankitol's release of solar energy stored in tossil Inels over geological time linked to the terrestrial mechanism ud soring and releasing hear and City withou the hydrosphere? Second, and perhaps nost importantly, is it possible that CCG-induced intrared absorption will exert an influence on climate primarily through alterations of stabilliy rather than simple bulk beating? If this is so, it is crucial that we determine whether lower stratospheric stability—scenningly capa ble of being probamidly aftered over at least a short 2 or 3 year period by a single major. volcanic eruption—is subject to a longer term CO<sub>2</sub> influence.

In the energing quantum view on the natime of climate, the son-earth system appears like a symphony being played by a multitude of instruments. These instruments are dehaed against a witlely varying backdrop of space and time, a fact that precludes a timeon mathematical description of their interacrivity when studied from the Newtonian paradigm. The quest of the climate theorist is not only to describe the individual instruments. but also to yield practical advice on how these components behave as a collective and highly

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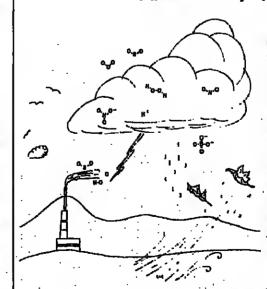
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## Appendix: The Laplace Transform

The leasis of this method is the transforma-

$$F(t) = \int_{0}^{t} f(t)e^{-tt} dt = If \qquad (A1) \quad Acknowledgments$$

The function F(s) is the Laplace transform of f(t), and the operator L that transforms f into  $m{F}$  is the Laplace transform operator. This formula represents a superposition of exponential functions,  $e^{-st}$ , where the superposition is over time t and a represents frequency.

To duplicate three solar cycles from 1954 to 1987, we begin with

$$\int_0^{\infty} e^{-4\pi + \epsilon t t} f(t) dt = \int_0^{\infty} e^{-st} e^{-t} f(t) dt$$

and note that this is equivalent to

 $F(s + c) = L[e^{-c}f(t)]$ 

F(c) = L[f(t)]

A property related to equation (A2) is  $L[f(t-c)] = e^{-is} L[f(t)]$ 

where the constant  $c \ge 0$  and f(t) = 0 for  $t \le 1$ 0. Equation (A3) can be used to obtain the transform of an admissible periodic function f(t) of period T > 0. We can then state the in-

 $f(t) = f_0(t) + f(t - T)$   $t \ge 0$  (A4) whose graphical interpretation is given in Fig-

This work is supported through U.S. De-artment of Agriculture Harch Project NY(C) 125442. Many of the scale interactive concepts came almot under NSF gram (GA-35250) and NASA contracts involving studies of severe local storm generation and numerical prediction. Joan Vyverberg Jensen aided in the preparation of the manuscript.

### References

Agee, E. M., Present climatic citoling and a crojosed causative mechanism, Bull. Am. Meteorol. Soc., 61, 1356-1367, 1980. Currie, R. G., Distribution of solar cycle signal in surface air temperature over North

America, J. Geophys. Res., 84, 753-761,

Dewey, K. F., and R. Heim, Jr., A digital archive of Northern Hemisphere snowcover, Nov. 1966-Dec. 1980, Bull. Am. Meteoral. Soc., 63, 1132-1141, 1982,

Diaz, H. F., Atlas of mean winter temperature departure from the lunguerm mean over the contignous United States 1805-1979. Natl. Climatic Center, EDIS, NOAA, Asheville, N.C., 1980

Errel, H., Ein neuer hydrodynamischec Wic belsatz, Afebrard, Z., 59, 277-281, 1912. Gage, K. S., and G. C. Reid, Sular cariability and the secular variation in the tropical tropopause, Geophys. Res. Lett., 8, 187-190, 1981.

Goldherg, R. A., A review of reported relationships linking solar variability to weather and climate, in Solar Variability, Wrather, and Climate, National Academy Press, Washington, D.C., 1982.

Hurt, D. V., Variations in sunspot structure and climate, Climatic Change, 2, 79-92,

Jones, W. L., and D. Houghton, The conpling of momentum between internal gravity waves and mean flow—A immerical study, I. Atmos. Sci., 28, 604-608, 1971. Kaplan, M. L., and D. A. Paine, A 32-km moist primitive equation model providing for scale interaction, J. Atmos. Xri., 30, 213-

Kerr, R. A., Sun, weather, and climate: A connection?, Science, 217, 917-919, 1982. Lincoln, J. V., Status of the current solar sunspot cycle, Eos Trans. AGU, 60, 1027, 1979. Lovelock, J., Gaia, Oxford University Press, New York, 1979.

MacGracken, M. C., and H. Moses, The lirst detection of carbon dioxide effects: Workshop summary, Bull. Am. Meteorol. Xor., 63, Mar, W. P., Jo., Maximum ennopy spend analysis and linear prediction of the Sequelianna Dealnage Basin runoff, M.s. Thesis, Reusselaer Polytech, Inst. Top

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Namiae, J., Nature and possible causes of the Neatherstern Vaited States drought in 1962-65, Mon. Weather Rev., 94, 543-5

Paine, D. A., How weather pattern folk sunspots, Cheutech, 12, 724-728, 1982 Paine, H. A., and M. L. Kajdan, The light of rendriscaled energy sources leading to mocpheric development, Sci. Rep. I, Sa. Sci. Foundation, Washington, D.C., 191 Paine, D. A., and W. L. Pensinger, Adyacal theory describing superconductan

Parker, D. E., and J. L. Brownscombe, Str.-spheric warming following the El Chicko cohemic emption, Nature, 301, 406-408.

DNA, Intl. J. Quant. Chem., 15, 333-34.

Sokolnikolf, L. S., and R. M. Redheller, Me ematics of Physics and Madern Engineering 2nd Ed. M. Graw-Hill, New York, 1966 Wiin-Nielsen, A. C., Meteorology and the oceans, Boll. Am. Meteorol. Soc., 63, 1526-

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Wheaties?

Mount Narrayer in western Anstralia at 4.2 billion years, the oldest date of a terrestrial ample (New Scientist May 19, 1983), How these dates will stand up vis a vis the idilest whole-rock dates (3.8 billion years for same ples from West Greenland) remains to he gen. The Mouot Narrayer date is for single grains extracted from a sedimentary ruck. The Greenland whole-rock dates were obnined by more conventional, though nunetheless state-of-the-art, mass-spectrometry

The concept of the ion microprobe in that bly dates back to the early 1940's RCA parents of J. Hillier. R. Costaining revived the ideas about electron and hon inicroprobes less than a decade later in his thesis research at the University of Paris, and he built prototype instruments. It has taken two to three decades since deen for the prunise of the ion microptobe to be realized. Quantitative iso-tope analysis of single crystal surfaces on a point-by-point basis may have far-reaching applications in broad helds of geophysics. Isotope ratios for age-dating purposes will be very powerful, as will isotope and unce-ele-

The new zircon dates are based on nranium and radio-decay product ratios. To be an excepted milestone in the studies of dating the earth, the rocks from which the zircon gystals were derived must be knuwn. The mplication is that the zircons originated from maks whose radio clocks were set 4.2 billion sears ago. Rather than a clearly documented geological observation, the new results are nore in the form of a porrent of things to come. Scientists will find it exciting when

there is hard evidence that the earth is as old The ion microprube represents a combinaion of the complex rechnologies of electronoo (static field) optics, surface-ion physics. nd the intricacies of the mass spectrograph twould appear evident that this combination has begun to function in the results of Comp-

sion and, indeed, of others who are pioneer-

# ing this great advance.—PAIB **IRAS Discovers**

Astronomers sifting through data sent to earth by the Infrared Astronomical Satellite (IRAS) have discovered an extremely faint omer that came within 210 million km of our sun on Januare 20. This is the second tomet to have been sighted by the satellite in

out being noticed now may be able to be

IRAS is a joint project of the U.S. National

# Streamflows at Record Highs

Streamflow was reported well above average in more than half the country during May, with flows at or near record levels for the munth in 22 states, according to the U.S. Geological Survey (USCS), Department of the

USGS hydrologists said that above average flow was reported at 98 of the 173 USGS key index gauging stations used in their monthly check on sucface- and ground-water conditions. High flows were most prevalent in the Mississippi River basin states and in the cast, with the exception of Maine, South Carolina and Georgia. Below-average streamflow occurred in the Pacific northwest and in small scattered areas in Colorado, Kausas, Texas, and Minnesota

The combined flow of the three largest rivers in the lower 48 states-Mississippi, St. Lawrence, and Columbia rivers-was 46,000 billion gallons during May. These three large river systems, which include the flow of the Missouri and Ohio rivers, account for runoff from more than half of the conteminous United States and provide a quick, useful check on the status of the nation's surface-water resources.

ly average or above average throughout much of the country, reflecting the abovenormal precipitation patterns of the past sev-

Working in cooperation with federal, state, and local officials, USGS hydrologists routine ly collect information on the quantity and quality of the nation's surface- and groundwater resources at more than 45,000 sites across the country. The highlights of May water-resources conditions are as fullows:

The Big Fice Rivers. Mississippi River at Vicksburg, Miss., 1,034 bgd, 88% above average and 35% above the April flow; Colum bia Ricer at The Dalles, Ore., 269 bgd, 312 below average, but 84% above last month's flow; Ohio River at Louisville, Ky., 215 bgd, 153% above average and 46% above the April Hoe; St. Lawrence River near Massena, N.Y., 182 bgd, 1% above average and 2% above last month's flow; and Missouri River ar Hermann, Mo., 135 bgd, 1275 above average, but 95 less than the April tlow.

2. New York. In upper New York time. watere from Great Sacandaga Lake spilled ocer the Conklingville Data for the hist time in its 53-year history. The overflow lasted 10 days, pushing the Hudton River to its highest

flow levels since 1936. North Carolina. Wet conditions contimed throughout North Carolina during May, and several major streams were well above average for the hourth straight mouth. flow of the French Broad River at Asheville. N.C., averaged 1.9 bgd, 39% above average for May, and flow of Contentnea Creek at Hookeriun, N.C., averaged 479 million gallous a day, 53% above average. Ground-water levels in the state were generally 2-6 fecabove the lang-term averages for May and were 1-6 feet higher than the levels this time

lawa, Wet conditions persisted in much of lawn. Flows of the Det Moines River at Fart Dodge, Cedar River at Cedar Rapids, and Nishnahoma River near Hamburg have

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been well abuve average now for Preouseun-tive months. The Des Moines and Cedar rivers act new record high flows for the month. Flow of the Des Moines River at Fort Dodge averaged 5.1 bgd during the month, the highest May flow in 51 years of record.

were varied throughout Minnesona. Streams in the northeastern part of the state were helow average, while in the sombwestern corner of the state, streams were above average. Flow of the Raint River at Maniton Ranials Minn., averaged 4.9 bgd thering May, 58% below average. To the couth, those of the Minnesota River at Jordan, Minn., aceraged 10.5 ligd, 195% above average, the second highest May How in 49 years, and the eighth straight month that flow of this stream has been well

abuce average.

6. Utali-Nevada. In the western United States, heavy rains and sharply warmer temperatures melicil record-deep mountain snowpack in Utah and Necada, resulting in torrential ranoff, severe floods, and need slides. Utali's land-locked Great Sali Lake ruse more than 7 inches in May, to its highest level since 1924 and more than 3 feet higher than the level at this time last year.

7. Washington. Streamflow through unst of Washington state was below average during May. Flow of the Skykonish River near Guld Bar, Wash., for example, averaged 3.2 hgd, 27% below average. This is the second straight mouth that the flow or this stream has been well below acerage.

8. California. Wet conditions prevailed across the entire state during May. All lice of the key USGS index ganging stations in California reported flows that were well above acerage for the month. Flow of Arroyo Seco near Pasadena, Calif., averaged 41 million galfons a day, the highest May llow in 50 years of record. In southern California, water levels in the key wells in Los Angeles and Santa Barbara counties were all above average. 'f he level in the key index well near Cuyama, in Sama Barbara County stood at 40 feet below the land surface, almost 74 feet above the lung-term average, and highest in 33 years of record. (Map courtesy of the U.S.

# Yews

# Leveling in Earthquake Area

The National Georletic Survey (NGS) is performing lirst-order geodetic leveling in the Coadinga, Calif., area. The project, which is being funded be the U.S. Gerdogical Survey (USGS), is intended to measure vertical height differences associated with recent Coa-

inga carthquakes. The largest of the earthquakes occurred on May 2 with magnitude 6.5 (Richter scale). More than 1,500 aftershocks hace followed. including two on May 8, which were magnitude 5.5. Damage estimates exceeded \$30 oillion (see Em, May 26, p. 387). No loss of life was reported, but 1,000 residents were

At the request at the USGS, NGS Mobile Field Party G-36 immediately began field reconnaissance and bench mark recovery operations. The lirst-urder leveling, which totals approximately 50 km, will be completed by the end of June. Where possible, new leveling will follow lines of leveling previously per-lorated in 1969 and 1972. This will provide an imlication of vertical height differences during the intervening years caused both by subsidence in the area from man-made cause and by vertical height differences associated with the earthquakes. The tlata will be analyzed by NGS and USGS. Reports of rhe analyses should be written in July or August.

# **STARE System** Looks at ULF Magnetics

STARE (Scandinacian Twin Auroral Radar Experiment) has analyzed magnetospheric ultralow frequency (ULF) wares in the ionosphere since 1977. STARE data analysis recently discussed by J. J. Singer of the Air Force Geophysics flaboratory, Massachusetts includes new explanations of the ascillations that occur in the diell structure of the genmagnetic field (Nature, May 5, 1983, p. 15).

The ULF unisations (periods from tens of seconds to 10 min) were thought to be standing hydromagnetic waves that resonate on geomagnetic field lines. Singer described of periods that increase as a function of lat-tude. This phenomenon may clarify the nature of their source and of the characterisms between indicidual oscillating geomagnetic shells. Singer roter the argument supporting the standing-wave theory as being the consistency of the wave periods with the time it takes Alfséti waves to travel along geomag-netic lleld lines between ionospheric rellecrion boundaries.

The STARE system, which is composed of two coherent pulse Doppler radars located near Molyik, Nurway, and Hankasalmi, fluland, measures the ionospheric electric liekt by making the radar signals reflect from electrostatic waves excited in the E region of the auroral zone. The radar jodses scattered by the electrostotic waves are Doppler shifted in frequency as a result of the electron  $E \times B$ drift velocity. Analysis of the scattered pulses yields ratues of amplitude and direction of the electric lichl in the region of overlap of the two radars. STARE has relatively high spatial (202 km) and temporal (20 s) resolu-tion. The system is very beneficial for these measurements in that it takes tlata over n large area (400° km) simultaneously.

Recent STARE observations described by Singer include a number of transient events whose joilsation shuwerl an increase in period with latitude. These events are apparently inruidal eigennoide oscillations, which are eastwest magnetic field perturbations. Because of Hall currents in the izmosphere, the oscillathats were abserved simultaneously as northsouth perturbations by a ground-based magnetometer. The observations are interpreted as being a simultaneous occurrence of oscillations from separate magnetic chells. Thus it was shown that magnetic field lines on adjacent shells can oscillate at different frequencies, implying only weak compling between the lines. These measurements were possible becaute the STARE system is free of ionospheric screening effects. Comparison with ground measurements may yield information about the attenuation and a reening phenom-

# **VLBI Observations**

From the centers of quasars calculated to have velocities III times greater than that of light-the Einsteinian constant of the universe—astronomers are finding explanations of Duppler effect red shifts of emission. Very long baseline interferometry (VLBI) arrays have been used to examine the cores of seven known railio sources in space that are characterized by superluminal relocities, and a significant amount of knowledge has been gained about real-shift phenomena of plasm sources. Milliaresecond resolution of VLBI techniques allows observers to examine in detail central structures of radio sources.

According to a discussion of observers at the recent superluminal workshop held at the Jodrell Bank Observatory, U.K., February 1983, "The last six years have brought a great increase in reliability of results, particularly because of the use of VLB( arrays..." (Nature, April 28, 1983). This reliability has resulted in a compilation of properties of ra-dio-source core structures. The steep frequency-shifted radio spectrum of a superluminal structure is apparently caused by rapid-ly extending plasma jets. The discussion provides the following explanation of a rela-ticitie jet: "...a relaticistically moving stream uf plasma emanating from the core. .. [whichl... is identified with the base of the jet.... The 'moving' compunents are shocks or plasminrs maring duwn the jet, which justing the ward the observers in the case of superluminal sources" (Mature, April 28, 1983). The idea is that illusions of Duppler effect real shifts ran be produced by high-energy physi-cal phenomena other than simple relocity effects. Even in the case of a source nurring nway from an ubserver with a relative vehicity less than the speed of light, an illusion of su-perluminal vehicity results because the angle if riew is small ("because the observer's riew of the early part of the attation is delayed with respect to the later parts, and hence the

apparent duration of the motion is shurtened" (Nature, April 28, 1983)1. Another effect that can cause illusory red shifts is the so-called "Doppler facoritism" phenumenon, which is o similar "small angle" effect that results in an enhancement of flux density. Cutiously, superluminal sources have nrc second jets located only in one side of the nucleus, as well as the central millaresecond jets. Thuse jets could be "Doppler favorites" or they could simply be unexplained properties of radio sources.

The research on these unusuni radio sources also examines the small-angle phe-

observed strengths of quasins to their line-ofsight angles; sources with weak radio cores and double outer lobes are at large angles and rice versa. A mumber of problems in ex-plaining "classical double" radio quasars have arisen from recent measurements.

There are many ideas emerging on how to explain the observations. Some observations can be explained if the jets are released from the cores as a sort of plasma spray, the angle of view being a function of visual collimation of a portion of the jet. Other observations seem to require the existence of single, nar-

Certain broad theory explanations include the origin of galactic phenomena. According to one such theory discussed at the workshop: ". . the Galactic Center, Seylert galaxies, and quasars are interpreted as reflecting just two intrincic parameters—the mass of the central compact object (black hole) and the accretion rate into it" (Nature, April 28,

# Year of Oceans?

John V. Byrne, administrator of the National Oceanic and Atmospheric Administration (NOAA), has propused that 1984 he ubserved as the Year of the Oceans. The year should be devoted to defining and chrifying the U.S.'s ocean and coastal guals and "rallying the support to achieve them," Byrne recently told oceanographers attending the Coastal Zone '83 gathering in San Diego, Cal-

"Today we see ferment in ocean and coastal concerns," Byrne said. Amnng the examples he cited was the proclamation issued by President Reagan on March 10 declaring an exclusive economic zone within 200 miles of the coast where the United States will exercise jurisdiction for the purposes of exploring, exploiting, conserving, and managing natural resources (Eos. June 7, 1983, p. 402). In addition, "legislation has been introduced to define the outer continental shelf, deep scabed minerals, ocean thermal energy, marine pollution, fisheries, and other oceanic concerns," Byrne said. "In both houses of the U.S. Congress, legislators are considering bills that would establish a National Oceans Policy Commission," he added.

NOAA's administrator also urged that sta nd private organizations share in the effort to provide strong marine programs. "Only with active participation and guidance by the private and state sectors can the federal government discharge its responsibilities effi-

# Earth Dating by Ion

The ion microprobe is an instrument that is fitally coming into its own in isotope and trace-element analysis of particulate mineral samples. The idealized ion microprobe would be able to analyze sample volumes of less than one cubic micrometer. The analysis would include major-element bulk composi-tion and the chemical formula of the mineral being analyzed. More essential, the analysis would also contain trace-element composition and isotopic abundances because the ion microprobe employs a mass specirograph as its analytical device. Ideally then, an investigator would be able to obtain major, minor, and trace-element data and be able to date geonomena. There are theories that relate the instantaneously and simultaneously. That this

### will select six to be pictured on Wheates hoxes. The charities of the cix linalists of two amateur astronomers for whom the coma is named, IRAS-Araki-Moock passed Earth In the last 11 years, flrace has run in 9 marathous and in two 50-mile races.

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William Boynton and Gerald Schubert,

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# Second Comet

atso-week period. Comet IRAS (1983F) was found by the orhing telescope on May 13 (GMT) and was enfirmed by ground-baced observers on May 19. The comet is one million times laimerthao comet IRAS-Araki-Alenek, which was discovered simultaneously by fRAS and the

Many faint comers that had previously passed through the inner solar system withsighted by IRAS in its year-long sky survey.

Aeronautics and Space Administration, the Neiherlands Space Agency, and the United Kingdom's Science and Engineering Research

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### Recent Trends in Hydrogeology, 1982

T. N. Narasimhan (Ed.), *Xprc. Pap. 189*, Geol. Soc. of America, Boulder, Calo., 348 pp.,

Reviewed by Mary P. Amleron

Recent Trends in Hidrogeology contists of a ser of papers presented during a birthday party on February 9, 1979. The birthday par ty, or, mare properly, the symposium, was convened to honor a distinguished hydrogeo logist, Paul A. Withertpoon, on his titth in thilay. Many of the papers were written by Witherspoon's former endeme as well as by his current colleagues at the Lawrence Berkeley Laboratory and the University of Califorma, Berkeley A preface by the editor (T. N. Narasimhan)

viovides an introduction to the volume and short commentaries on each of the 23 naper as well as ideas on probable future directions in hydrogeology. According to the preface, the purpose of the symposium was "to attempt a reasonable coverage of the important facets of hydrogeology" and "to provide a global picture of hydrogeology" where hydro-geology is defined as "the discipline conerned with those geologie processes that are subsurface water. Hence, the material covered in this volume is broad, ranging from topics traditionally associated with hydrogeology, such as well hydraulics and regional flow system analysis, to more exotic subjects, such geothermal resources and induced seismic ity. As a result, only those with the most catholic interests will read all 23 papers.

However, all hydrogeologius are likely to relish the excellent critical review articles on contaminant migration in saturated unconsol idated material (R. W. Gillham and J. A. Cherry); statistical characterization of heterogeneous aquifers (S. P. Neuman); and flow test evaluation of fractured reservoirs, in which A. C. Gringarten presents a synthesis of methods, drawn from the reotechnical, geological, and petroleum literature, fur evalunting the transmission properties of fissured formations. These three papers represent state-of-the-art summaries on three of the "hottest" new areas of hydrogeologic r search. Most hydrogeologists will also be in-terested in R. A. Freeze's synthesis of groundwater-stream relationships using de-terministic and stochastic concepts, J. E. Gale's compilation of hydraulic conductivity measurements for fractured rock, and per-spectives on regional flow system analysis by Bredehoeft, Back, and Hanshaw.

Of more specialized interest are T. N. Narasimhan's insights into numerical modeling techniques as well as his lileas on the physics of unsaturated flow and D. C. Helm's paper on land subsidence. Others will be interested In papers on annivitcal solutions, well test in-strumentation, the relationship between well loss and skio effect, groundwater problems in mines, and physical properties of porous ma-terial. There is also an informative summary terial. There is also an Informative summary of past and current studies incolving atomge of energy in the form of relatively hot or cold water in aquifers (Tsang and Hopkins), as well as a lengthy paper by T. D. Show investigating the causes of induced seismicity upon reservoir filling, and four papers on various aspects of geothermal resources. In addition to the papers on fractured rocks, there are two other papers addressing problems associ-ated with disposal of high-level radioactive

waste in a subsurface repository; an occryiew hr S. N. Dacis and a paper on isotopic dating a groundwater in crystalline rock by P. Fritz. Last, there are a momber of units conversion tables at the end of the look. From a 1983 perspective, the current

trenth in bydrogeologi, that are accurately re-Hereil in this collection of papers presented in 1979 are contanying or ungration. How through fractured rock and other aspects of unclear waste isolation, and stochastic processes. It could be argued that the other papers, which when taken indicidually are not really representative of strong frends in lodrogeology, when taken as a whole do reflect another corrent trend: the increasing interaction between hydrogeologists and those in related disciplines such as petroleum engineering, mining engineering, and toil mechanics. However, it is more significant that the volnine does not contain any major papers addressing one of the strongest current frestly in hedrageology, deciphering and quantitying chemical reactions in the substitute. There are sections on hydrogeochemismy in the lengthy review paper by Gillham and Cherry and in the paper by Bredehoeft et al. There also is a fairly specialized paper examining the chemical problems involved in the reinjection of geothermal brines, but there are no general review papers on chemical reactions in the cubsurface. Perhans the absence of papers on this subject suggests than questions related to hydrogeochemistry are some of the most difficult to address and

The book measures 8½ x 11 inches in size, and the rext is presented in two columns per page. The pages were produced from camera-ready copy generated by a word proces-sor; figures and lables are well dune throughout. While the print is crisp and clear, the lines of type are single spaced, causing a lot of material to be packed onto each page. which may cause some eye strain with prolonged reading. The price may seem a bit steep, but at less than 8 cents a page, the book should be considered a bargain

Mary P. Anderson is with the Department of Geology, University of Wircousin-Madiron, WI

### High-Precision Earth Rotation and Earth-Moon Dynamics: Lunar Distances and Related Observations

O. Calame (Ed.), D. Reidel, Hingham, Mass., xix + 354 pp., 1982, \$125.

Reviewed by John M. Wahr.

The last decade or so has seen the inactical development of a number of high-precision. space-related geodetic techniques, specifically, lunnr laser ranging (LLR), satellite runging, and very long baseline interferometry (VLBI). One consequence has been an enlarged and improved data base available for studies of lunar motion and earth rotation.

The impact on lunar studies has been particularly striking. The vast improvement in lunar positioning data provided by the LLR experiment has revived interest in the previously lethargic business of modeling the lunar orbit and librations (librations are rotational displacements of the moon about its center of news.). Several numerical and analytical mod-

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els of the orbit and librations have been rleveloped over the past few years. Numerical models, constructed by manerically solving appropriate differential equations, are gener ally mure accurate than existing analytical models and are, in principal, bener spired to removing the effects of limar mation from the LLR residuals. On the other hand, results from numerical models are less amenable to physical interpretation, and stranslytical naidels continue to receive attention. Analytical models are particularly useful in trying to understand the linear librations, both because of the possibility of excited free librations and because the dynamical behavior of the moun during the forced librations is not completely

So far, the new gendetic techniques have had less of an effect on earth rotation studies. Rotation data from traditional optical astromenry are still competitive at periods of a few months and langer. The most pronounced advantage of the new techniques is their ability accurately to determine changes in nutation (i.e., pole position and rotation rate) at perioils between a few days and a few months. But it appears that must of the geophysically useful signal occurs at longer periods.

Both lunar metion and earth rotation results derived from the new techniques were discussed at the International Astronomical Union (IAU) Colloquium 63, held in Grasse, France, during May 22-27, 1981. This lunck constitutes the proceedings of that collegei-um. It will probably be of little interest to people who have no working knowledge of the held, primarily because, in common with other conference proceedings, the 37 contributtons here are short and not designed for a general audience. (There are some argualde exceptions, most notably a summary by J. Henrard of existing analytical models of the lugar orbit; a presentation by D. S. Robertson and W. F. Carter describing results from VLB1; and contributions from J. Diskey, H. Fliegel, J. Williams, and G. Yorler describing the Jet Propulsion Laboratory (JPL) reduction of LLR data.t

But an additional factor here is that the subject has not yet developed to the point where results can be routinely interpreted in terios of geophysical or hinar processes. The reader expecting to learn anything generally useful about the earth or moon will be disappointed. On the other hand, the book does give a representative picture of the current state of the subject. And although the held is rapidly esolving, the problems and tech-niques described here will probably be around for some time.

It is not possible to provide more than a brief description of the coments of these proceedings. 1A more complete discussion can be lound in Bynn Tapley's report on the colli-quinm published in Eus., January 26, 1982, p. 132.) Most of the earth retainin work presented here is concerned with the data analysis. There are contributions from groups at JPL, the Massichusetts Institute of Technology, and the Centre d'Études et de Recherches Géodynamiques et Astronomiques describing their current elforts at reducing the LLR data. There are discussions of the analysis of VLBI data and of data obtained from ranging to the GPS and Navy Navigation satellites. (Two presentations describing results from ranging to the LAGEOS satellite are presented here by abstract only.)

There are also several attempts to combine and compare rotation tlata derived from competing techniques. Other earth rotation contributions include a description of Chinese efforts in the field, discussions of the 1980 IAU nutation series, and a description by J. Williams and W. Melbourne of a possible future problem associated with adopting fixed precession and equinox corrections, The nne case here where the results permit

ley et al. relating variations in the earth's rotation rate to changes in atmnspheric angular monoculum, is represented in these proceedings by abstract only.

Most of the lugar motion studies are concerned with modeling the hipar orbit. Most important is probably a description by J. Chaprunt and M. Chaprent-Tonzé of their inproved analytical model that includes the ellects of planerary permebations. Other orbita studies include quantitative comparisons of numerical and analytical models and discussions of the robinal effects of earth tides and general relativity. The rore attempt to use the observed orbital results to learn new physics is a study by T. C. Van Flamlern at a possibly changing gravitational constant, but it is represcuted here only by its abstract.

Lunar libration results are more immediarely accessible to useful physical interpretation than are the lunar orbital studies but are not nearly as well documented in these proceedings. D. H. Eckhardt describes an improved analytical libration model that includes the planetary and earth figure perturbations. The other libration-related contribution, a general review by R. W. King, is represented here by abstract and biblingraplay only. Other hunar and orbit-related studies are discussions of selectedeth reference frames and a development by R. Bruucke and W. Preder of a small parameter expansion of the disturbing function for the three

John M. Wahr is with the Department of Physics and the Cooperative Institute for Research in Encitonmental Sciences, University of Colorado, Brind-

### Isotope Studies of **Hydrologic Processes**

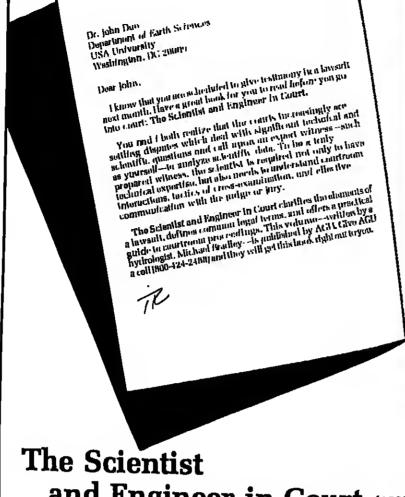
E. C. Perry, Jr., and C. W. Munigomery (Eds.), Nuthern Illinois University Press, 118 pp., 1982, \$25.

Reviewed by D. I. Siegel

During the past decade, the study of enviunmental isotopes has become an increasingly powerful tuol toward understanding hychologic processes. The present book, a selection of twelve papers presented at the 1980 Midwest American Geophysical Meeting, is a useful addition to the literature of isotopic methods used in levelrologic studies and will be of particular value to those interested in groundwater flow system analysis aml groundwater chemistry.

The papers deal with the stable isotopes of oxygen and hydrogen in water; carbon in bicarbonate; sulfur in sulfate and sulfate; and the radioisotones of uranium, hydrogen, and radium. The hist paper, by the editors, provides a brief had succinct introduction on isotopic processes. Of particular interest to this reviewer are papers by Perry et al. and Desaulniers et al., who explain isotopically light groundwatet (है। O about ५% lighter than modern recharge water) in Illinois bedrock aquifers ami clayey Pleistocene deposits in south-central Canada as Pleistocene recharge during colder climates. Desaulniers et al. used 14C to demonstrate that the isotopically lighter waters in the Pleistocene deposits

rould be up to 13,000 years 8.P. Not all hydrogeologic systems are so relatively well defined isotopically. Fritz and Frape show that Ca-Na-Cl brines, found in bedrock on the Canadian Shield, are isotopically heavy, and plot above the "meteoric waterline" on a 815O versus 8/mdD diagram. The genesis of these waters is unknown, but bly related to rock/water interaction. Rock/water interaction in the active Ngawha geothermal system in New Zealaml is iliscussed in detail by Blattner who shows that



and Engineer in Court (1983) by Michael Bradley

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a positive shift in  $\delta_{18}O$  in the genthermal waters can be nonuniquely explained by interac-tion of reservoir rock with both meteoric and magmatic waters. Similarly, a paper by Krothe on sulfur isotopes in groundwater sys-tems on the Ogallala Formation, southwestern Kansas, and the St. Louis limestone in southern Indiana illustrates the difficulty in differentiating among isompic sources, sinks, aml modifying geochemical processes.

The only paper on isompes in surface water, by Sklash and Farvolden, is mainly a summary of their previous work, and restates the hypothesis that a major portion of stormflow in small watershells may be groundwater. The proposed cause of accelerated groundwater discharge during storms is the growth of transient groundwater "ridges" or mounds near the stream. Although this hypothesis may be considered provincative to some hydrologists, studies of hydraulic gradients near lake shores also have shown the existence of transient groumlwater mounds alter large storms.

Papers on radioisotopes are equally varied

ni content. A paper by Michel et al press gamma ray spectroscopy as a method tode teymine activities of <sub>228</sub>Ra and <sub>228</sub>Ra. Unit mir and radon concentrations in aquifer a cast-central Minnesota are described by Inc ly and Morey, and Gilkeson and Coward is lated manining disequilibrium to redex pass tial along a groundwater llow path is some costern Illinois. Tritium was used with subsolupe data by Stewart and Downes to item ly different water masses in a spring in No.

Instupic Studies of Hydrologic Processein? hook that presents some interesting work diremph case stroller as well as informati n more general name for the scientistick esterl in learning how to use hotopes as 2 M in hydrologic research. The cost of the hos however, may limit whilespread distributes A soft cover edition would perhaps hat he more Killing.

D. I. Siegel is with the Department of Goods Syracuse University, Syracuse, NY 13210.

University of Colorado, Boulder, Geochemist Pusifloa. Geochemin with active research program,
spile isotopes, radicateliee isotopes, analysis are elements is being sought for a joint approintment in the
pepartners of feedbagk al Sciences and the Longerpice lustitute for Research in Environmental Sciences (CRES) of the University of Colorado.
The one-half fine position within the Department
of Geological Sciences is tentre track at the assistant
of associate professor level with a starting salary of
\$12,000-\$15,000 for the academic year.

Teaching load will be balf that al Individue laculof. The position within CRES will be as a Fellow
with appropriate office and laboratory space. Ourcbif academic rear salary will be guaranteed by

sib appropriate nare and those an appropriate for start start will be guaranteed by CRES for two years at the departmental tage, after she incumbed most generate his/let CIRES salagenucument asset general material was augment from exemal sources, becombern may augment day further by generating three mounts of sum-er salary from contracts and grants, and consult-

ing Applicans with experience, publications, and/or movable existing research symposery preferred. Preferred starting date would be January 1, 1984. Closing date for applications is October 1, 1983. Applications should include statement of research and leaching interests, experience, a full vitae, and four letters of reference.

on letters of reference.
Apply to Professor Charles Stern, Chairman,
Apply to Professor Charles Stern, Chairman,
Apply to Professor Charles Stern, Chairman,
Apply to Sciences, Campus Box 230, University of
Aborado, Boulder, CO 80309.
The University of Cadorado is an equal opportu-

Research Scientist for International Ground Water Modeling Center. A position is in mediately available for a Research Scientist in the International Ground Water Modeling Center. IGWMC is an international information center for ground water modeling. It organizes an annual operates a clearinghouse for ground water models, conducts a program in applied research ou ground water modeling, and publishes the Ground Water Modeling Newletter.

The successful aplicant will have a Ph.D. in Civil The successful aplicant will have a Ph.D. in Civil Engineering Hydrology with a background in quantative ground water hydrology, including chemistry of ground water. The person must have a least one (1) year experience in modeling flow and cransport processes and should be arquainted with related recent research. A solid background in numberical and stochastic analysis is required.

Incumbent will perform the applied research program of the Center, including exploiting modeling feeds and research trends, and technical evaluation of models, and will be involved in the continuous applating of programs, and in huntling information requests.

tequests.

The annualized palary for the position is \$28,000 for a \$7.5 work week, typoically from \$30 a.m. to

tor 2 37.5 work week, typoteany atom 1500 p.m.
Interested applicants must include 111 number 012860 and social security number in a response by Jah 28, 1983 to:
Indiana State Engplorateur Service
10 North Schate Avenue
Indianapolis, Indiana 41520 J
Attention: W.F. Shepherd

Argonne National Laboratory/Chemistry Division. As immediate postductoral position is available for amospheric rhemistry studies based on mass spectrometric analysis of the stable isotopic composition of atmospheric trace gases. Problems methode source budgets and composal variations of atmospheric trace gases and electromination of atmospheric abelieve radical concentrations using stable isotopic tracers. Experimental techniques involve preparation of gas samples derived from trace gases using carrier gas train systems with cryogenic and demical separation methods and precision mass spectrometric analysis. Send resume no Mr. Walter Wefall, Perronnel Division, Box D-CHM-80, Argonne, Illinois 60439.

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Portdoctoral Position/Naval Postgraduate School.

The Ocean Turbulence Laboration has available a postdoctoral position for a person interested in the analysis and interpretation of oceanic turbulence data. The tenure is for one to two years. The successful candidate should have a Ph.H. in physical oceanography and although experience with turbulence data is preferable it is not essential. The opportunity for involvement in data gathering expeditional aboravalable. Resumes can be sent to Dr. R.G. Lueck, Carle 68Ly, Naval Pottgraduate School, Munterey, CA 99940

An Equal Opportuoity/Affirmative Action Fin-

Announcements

lathian Drogen" will be held June 23-30.

ence will focus on the origin, significance,

logical settings. The importance of careful field observations in deciphering melange

terraines will be emphasized. As such, much

of the conference will center around in situ

The conference will begin on Newfound-

land's west coast with excursions to melanges

ment of Ordovician allochthons onto the an-

tieni cominental margin of North America.

Next on the agenda is the Burlington Penin

Inta, where scientists will be able to examine

Polydeformed and metamorphosed melanges

and associated olistostromes deposited imme-

distely after the destruction of the margin.

The final field area will be the controversial

associated with the assembly and emplace-

field discussions; Newfoundland offera a

and its melanges.

New World Island

Research Professor is Marine Geoscience/University of Rhode Island. The Graduate School of Oceanography invites applications for a research professorship to Marine Geoscience whose salary and rank are negotiable. Preference will be given to cambidates who have clearly demonstrated abilities and interest in, but not necessarily limited to paleunaguetism. The position is funded by contracts and grants, havever the research professor holds full farthy rights in addition to other benefus. The paternaguetic facility at GSO is fully equipperf, fully operational and onemed towards rapid measurement of large mumbers of soft sectimentary samples. Applications are now open for the position which will become arailable about jarnary 1, 1984.

Send letters of application, resume, and trames and arbifresses of three professional references to: Roger L. Larsott, Graduate School of Oceanography, University of Rhode Island, Narraganseil. Ritoric Island 02882.

An aftermative action/equal opportunity employer not.

Sciential i/National Center for Atmospheric Research. The work under the supervision of the reactive gases project leader. Will plan and oversee major elements of field experiment; develop analytical techniques appropriate to field and laboratory use; and analyze, interpret and nodel the data gathered. Requirements include: Ph.D. in atmospheric science or equivalent knowledge and skill, with a strong basic knowledge and skill, with a strong basic knowledge and skill, with a strong basic knowledge of atmospheric chemical and chemical kenetics; skills in research tlemonstrated by publications; skills and experience in analytical echemicary of acrosol and gaseous and aqueous atmospheric sobstances; skill in cleslin, testing and implementation of chemical analytical techniques; skill in development of computional models parameterization of atmospheric, physical and rhemical processes, and application of unmerical and statistical techniques. Scientis I appointments are four term of up to three years. Individual may be appointed to the next higher level of scientist in accordance with the UCAR Scientilis Appointment Policy. Salary: \$25,814 to \$37,722 autmally. To apply romact: Eather Balzon. (303) 494-5151 extension 584 or send resume and list of publications to NCAR Employment, P.O. Bex 3010, Pumbler, CO 80307.

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Physical Oceanography/University of Rhode ta-land. A postdoctoral research associate position is available starting Ortober 1, 1983 for studies of tropical processes in the Parific. The research in-colves the collection and analysis of data relating to the dynamic topography and zonal pressure gradi-ents of the equatorial current systems as part of a long-term study of ocean influences on climate. Submit resume and professional references in Au-gust 15, 1983 to: Dr. B. Raudolph Wans, Marine Research Associate 11 Position, UNIVERSITY DE RHCIDE ISLAND, P.O. Box 357, Kingston, Rhade Island 19884. An affirmative action/equal opportunity emplorer

towa State University of Science and Technology, Department of Earth Sciences/Research Assorbate;

Department of Earth Sciences/Recaren Assortine; Electron Microprobe. The Hepantineon of Faith Sciences invites applications for a Research Asso-tiate position as att electron thicroprobe specialist. The appointment will be a fully funded, permanent, twelve-month position. Salary will be commensurate with qualifications.

Primary duties are the operation and mainte-nance of a fully automated microprole with WDS and EDS rapabilities and the supercision of avorta-ed laborators facilities. Additional duties include the struction of research personnel in instrument op-

instruction of research personnel in instrument op-eration. Ample opportunities exist for conducting collaborative and independent research torodying the inicroanalysis of geological materials. Applicants should have a M.S. degree in a science or engineering field, or equivalent experience, and experience with electron heam instrumentation. Persons with a working knowledge of WDS and EDS spectrameters and the acrompaning computer operations and experience analyzing geological sam-ples will be preferred applicants. Application deadline is July 31, 1983, Later appli-cations will be accepted it the position is not filled. Applications should include a romplete resone, a statement of background and interests, topics of publications and trames of at least three references. Appliculums should be sent to:

collans should be sent to : Bert E. Nordlie Department of Earth Sciences

Iowa State University Town State University is an equal opportunity/af-firmative action employer.

Faculty Position in Mariae Geology/University of Maryland, Centur for Environmental and Estuariae Studies (UNCEES). Hone Point Fustronmental Laboratories of UMCEES invites applications for a tenure track research faculty position trank open; for a marine geologist. The successful andickne will join a growing physical/geological occanograph; program, so applicants with a wide rategy of interests will be considered. Diprotunities exist for interests will be considered. Diprotunities exist for interests will be given to caulifulate with interests in estratine and continental shell sedimentological processes, the primary cruerion for selection is the ability to develop a strong research program. The closing date for applications is August 1, 1983. Farriculum ritae, description of research program. The closing date for applications is August 1, 1983. Farriculum ritae, description of research regions and list of references should be sen to:

Dr. Larry D. Ward

Chickes

Horn Point Environmental Laboratories

Florn Point Environment of Laboratories
P.D. Box 775
Canduidge, Maryland 21613.
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Professor of Meteorolgy/University of Maryland.

The Department of Meteorology at the University of Maryland, College Park, invites applications for a tenure line Professorship. We seek a well-established, highly reconstructed scientist with an outstanding international reputation in autospheric and oceanic modeling and applications. We propose the establishment of a renter to study the interactions of atmosphere, ocean and land processes and their impact on clinate cariability, and its particular to study the feasibility of short term climate predictions. The applicant should be qualified to lead such a Center, plan its projects, organize its activities, and bring to the University the necessary requirees to attract ourstanding scientists to the Leanet, and bring to the University the necessary re-univers to airract ourstanding scientists to the Len-ter and to carry out its cessards fourtions. Salary is negatiable. To apply, please send a complocic vitae and the names of references to the Chairman, Search Committee, Repartment of Meteorology, University of Maryland, Fallege Park, MD 20742. Applications received by 22 july 1983 will receive full consideration.

the Constraint of Maryland subscribes to policy of equal educational and engloyment organizative. The University of Maryland is requeed by Title IX of the Education Americhment of 1972 not to dis-criminate on the basis of sex to admission, treatmen of students or employment.

Chairman—Department of Geological Sciences, Wright State University. The Department of Geo-logical Sciences, notice applications for the posts of of Chairman, to be appointed September 1984. We serk a demande universal with administrative tabor and an appreciation for research and practice-relaed educational activities. Rank is at the full profesear containing a firm communicate to basic re-seas of specialization. The department is active with 12 laculic and an emphasis on professional practice, termannaming a firm communicate to basic re-

Send a letter of application, corricolour virae and Charman, Search Commune

Department of Geological Sciences Wright State University Bitton, OH 45435. Wright State University is an allocatative as now regul opportunity employer. Closing date for the pusition is October 31, 1983.

University of Arizona/Faculty Position. The De-partment of Hydrology and Water Resources incires applications for a faculty position in hydrology with a specialty in ground-water obening I. Landilates must have training and/or professional experience in hydrogeology and must have demonstrated addi-ties in the quantitative aspects of the topic. Appoint-ment will be at the level of an assistant or associate professor. Interessed individuals should obtain fur-ther information from:

A win to the control of the control

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Marine Research Associate 11. Analyze and inter-pret time series of certical acoustic travel time and bottom pressure. Prepare progress reports and sci-enufic manuscripts on these results. Assix in plan-ning experiments and participate in scientific cruises. Ph.D. in physical occumography plus experi-ente in computer programming with times series

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applications in FORTRAN. Sobrist application and resource by August 15, 1083, to: ftr. O.R. Watts, Marine Research Associate 11 Position, University of Rhode Island, P.C. Box 357, Kingston, Rhode Island An affirmative actios/equal appartunity employer

STUDENT OPPORTUNITIES

Graduate Assistmaships/Howard University.
Howard Universite in Washington, ILE, offers a new graduate program for the M.S. degree in geoscience; mode possible let a grant from the Gulf Company. Areas of specialization are held geology/geophysics, geochemistre, and mercordogy/hythrology with remote sensing. Some stiperods and assistantships are available. Potential students slouds with the to Dr. Eris Unistedferson, Department of Geology and Hengingdry, Howard University, Washington, H.C. 20059.

SERVICES, SUPPLIES, COURSES, AND ANNOUNCEMENTS

Ground Bused Airglow and Aurora Optical Science Facilities Workshop. U.S. arglow and autoral scientists interested in ground based copical observations have formed a facilities definition group secrations have fortiged a facilities definition group. Their main purpose is to assess the need and to plan for the development of modern state-of-the-art lar littles to but their the meestigation of the major scientific problems within the field. The group selected by, I ve Broadhou tt'SC-busson as charman, It G. Rotonck (Fort A. Farbanko) as secretars. Br. W. Hatosen (Unic. of Texas-stalks), R. Eatler (Boston College, The sum Hill), G. Hetrandez (NOAA-Boulder), M. Tour (Utah State-Logan), P. Hars (U of Michigan-Ann Arbort and R. Roble (NCAR-Boulder) members of the organizing committee.

millee.
An initial workshop has been schedoled for Au-gust 1, 2, and 3, 1983 in Logan, Fish. The format will consist of invited speakers to review, chemous and dimands of the stratosphere, merosphere and and thumbs of the state-place, heresphere and thermosphere; chemistry, modeling, spectroscopy and applications to the magnetosphere in autoral physic; and corrent ground based farilities tyics and instrumentation; used in interference it; spec-troscopy, photometry and images in airglow autocal

The intent of this workshop is to indiate the de-The intent of this workshop is to initiate the de-reclopment of a working paper describing the scien-illic goals, the implementations policies, and the de-scription and location of the major tacilities steeded within his field. Also to be included will be a riscus-sion of the steed for enhanced consumuration with-in this group of scientists; the possibility of more formal organization; and the inviousle for an annu-al popular meeting.

formal organization; and the invonale for an annual topical meeting.

A complete agenda will be distributed to all scientists on the current mailing list. Anyone wishing to obtain further information can contact any member of the organizing commutee. All scientists interested in this area of aeronomy are invited to attend. Specific details on the workshop will be available and distributed by the first week in July.

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For lurther information, call tell free 8001. 124-2488 or, in the Washington, D. C., area,

POSITIONS AVAILABLE

Postdoctoral Position in Igneous Petrology/North-ern Illinois University. Position is for one ut two years. Position involves collection and sanalysis of georlienical data on basic plutonic rocks, but time will be available for writing and reveach on inde-pendent projects. Experience with probe. XRF, INAA, and geochemical modeling of igneous rocks is preferred, candidates willing to reach an infroduc-tory petrology course during spring somester will be given preference. Surfing date will be August or: September, 1985, depending on availability of car-

- 1 Sign

didate. Application deadline is July 15, 1983, al-through search will continue until position is biled. nion/equal opportunity employer,

experience desirable.
Prease send resume to: K.F. Klenk, Systems and Applied Sciences Corporation, 5809 Annapolis Road, Hyansville, Maryland 20784, or call (301)

An equal opportunity employer.

Postdoctoral Position in Atmospheric Chemistry and/or Cloud Physics/Georgia Institute of Technology. Recent Ph.D. scientifis interested in the development of theoretical models to study the chemistry and physics of precipitation are taylited to apply to the Georgia Institute of Technology.

The salary is \$18,000 year; period of appointment is one two years. Applicants should send vita and statement of research interests and the natures of two references to: Professor W.L. Chameldes, School of Geophysical Sciences, Georgia Institute of Technology, Atlanta, GA 30332.

GEORGIA INSTITUTE OF TECHNOLOGY 18 AN EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMOPLOYER.

1. 图像数据证明的

Sent resume and names of three referees of crop-fessor J.H. Berg, Arting Chair, Department of Good-ogy, Northern Illinois University, Dekalli, H. 181115, Northern Illinois University is an alternative ac-

Meteorologian Lead Scientist/Manager. To lead a group of meteorologism and programmets working on a variety of tasks related to meteorological modeling for weather force asting, sacilite clast assimilation methods and mesocrale meteorology.

Ph.D. in meteorology, experience in assimilation/objective analysis, weather forceasting models, and related computer programming/municriral techniques required. Vector-computer and supervisory experience desirable.

Please send resume to: K.F. Klenk, Systems and

Research Scinntist/Spnen Plasma Physics, Universi-Research Scinntist/Spnen Plasma Physics, University of Iowa. A research position is available in the Department of Physics and Astronomy. The University of Iowa, for theoretical and interpretative studies of waves in space plasmas. Sperific emphasis is on theoretical investigations of wave-particle inveractions in planetary magnetospheres and in the solar wind. These investigations are to support the interpretation of data being obtained from spacecraft projects such as Dynamics Explorer. International Sun Earth Explorer and Voyager. The applicant must have a Ph.D. with good qualifications in plasma physics theory and showd have some experience in the interpretation of space plasma physics data. Send a resome and the names of three references Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa 52242, telephone 319.

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Research Positions for Mathematical
Physicists. Applications are invited for several research positions at the Center for Studies of Nonlincar Dynamics, La Jolia Institute, beginning summer
1933. Current research involves work on nonlinear
wave propagation in random media, and fluctuation
phenomena in the stutistical mechanics of chemical
and geophysical systems. Physicists and applied
mathematicians who are interested in working on
problems of the above type should send resumes
and arrange for three letters of recommendation to
Josia Institute, 8950. Villa La Jolia Drive, Suite 2 jou.
La Jolia California 92037.
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Research Associate/Petrography-Petrography
join a research effort almed at understanding in
condensation history of the soler system by miner
ogical, chemical, and isotopic studies of ting indisions in primitive meteorites. Applicant need
have previous experience with meteorite but a
have previous experience with meteorite but a
have the but as the statement of the side of of rch Associate/Pet should be a superb petrographer, skilled in the st of the SEM and electron probe. Successful and date will be dedicated, productive, an effective of municator both orally and in writing, and will be Ph.D. In hand. Vacancy expected in iste number of early auturn 1983. Send resume and names of three reference it. Grossman, Department of the Geophysical Conversity of Chicago, 5734 S. Ellis Avenus, Obs. 11. 60637.

The University of Chicago is an equal opposite Hydrogeologist. Converse Consultants is selected a staff or project level hydrogeologist for facety and supply those involving groundwaler quality and supply waste disposal, mineral and energy development and geotechnical projects. Las. Vegas-based, will and geotechnical projects. Las. Vegas-based, will ascree primarily in the southwestern U.S. Opportunity for interaction with an expanding staff of provisionals in six regional offices. Excellent salary and six advancement potential.

Minimum requirements are an advanced degree. Minimum requirements are an advanced in the land of the proposition of the pears experience in the project of the pears o

Minimum requirements are an advance in the in geology plus two to five years experience into in geology plus two to five years experience in the sum and modeling and well field design; quantitative evaluation of groundwater flow, contractor supervision, coding or experience in geophysics and hydrology is ing or experience in geophysics and hydrology is desirable. Confact Dr. Robert F. Kapimond 1955 pal Geologist, Converse Consultants, inc. 1955 spencer Street, Suite 120, Las Vegas, N. 1956.

<u>Meetinas</u> Interspersed with these field trips will be formal and informal discussions on the ori-gin, significance, and correlation of melanges Penrose Conference along the Appalachian orogen; romparisons The Geological Society of America Penrose of Appalachian melanges with those of other

Conference entitled "Melanges of the Appaorogens; and general melange topics such as des of origin and structural and strati-1984, in Newfoundland, Canada. The confergraphic characteristics. For more information, contact, before Feband characteristics of melange in distinct georuary I, 1984, Brenna E. Lorenz, Department of Earth Sciences, Memorial University Newfoundland, St. Johns, Newfoundland A1B 3X5 Canada, Lorenz, Nick Rast (in the geology department at the University of Kentucky, Lexington), and Harold Williams (in good cross section of the Appalachian oroger the earth sciences department at the Memorial University of Newfoundland, St. John's,

# **Ophiolites**

The working group on Mediterranean ing at the Istituto di Mineralogia, Petrografia e Geochimica, in Florence, Italy, on Decemher 15-17, 1983.

Newfoundland) are the convenors.

associated with the deformed easierly edge of the ancient continent; the melange of imbri-Focusing on oceanic rectonics and metatated ophiolite that comprises the suture zone. morphism, the meeting will consider the structural and metamorphic history of ophiobetween continental and oceanic terranes; 1 'L lites during the period between their forma-tion and their involvement with the continenlal crust. Similar events in present-day ocean-Cambro-Ordovician Dunnage Melange, locatle settings may also be discussed. ed in the easternmost part of the ancient oce-

Abstracts, not to exceed one typed page, should be submitted by September 30, 1983, Mic terrane, and the Silurian olistostronies of to Giovanni B. Piccardo, Istituto di Mineralo-

gia, Petrographia e Geochimica-Università, via La Pira 4, 50121 Firenze, Italy. All abstracts and papers, whether or not accepted for presentation at the scientific session, will be published in a special issue of Opioliti.

## **Hydrologic Forecasting**

The American Water Resources Association (AWRA) symposium entitled "A Critical Assessment of Forecasting in Western Water Resource Management" will be held in Seatile, Wash., on June 11-13, 1984. The aympo sium will focus on the science of hydrol and demand forecasting and its relationship and significance to operational, planning, a policy decisions by both the public and the private sector in the western United States.

A session on the operation of water resource systems will focus on the use of very short-term hydrologic and demand forecasting for the improved operation of existing systems. Among the topics to be included are short-term river flow/river forecasting techques, long-term (mouthly to seasonal) munoff forecasting techniques, and methods to incorporate forecasts and forecast uncertainty

in system operation policies. Another session, on capital program plan ning and implementation, will focus on the planning of capital facility expansion for water resource systems. Among the topics to be covered are long-range and very long-range water demand forecasting techniques; evaluaung trends and uncertainty of social, economic, and technological factors, and their relationship to water tlemand forecasting; and methoda for evaluating the economic lass from failing to meet demand growth.

Abstracts, not to exceed 200 words, should be sent no later than November 1, 1983, to the general chairperson, Gary R. Minton, Lynn Street, Scattle, WA 98109.

# AWRA Conference

The American Water Resources Assuciation (AWRA) will conduct its Nineteenth Aninial Conference and Symposium on October 9-13, 1983, in Snn Autoniu, Tex.

. The conference on unplysis and management of land drainage and fluod waters will fenture 20 technical sessions on such topics as ulanning for stormwater ranoff; onn point source water pollution problems; stortnwiter quality, flood plain management, and flood control planning; water resources coniputailons by microcomputer; and remnte sensing as a planning tool. Fifteen technical sessions on regional and state water resources planning will deal with such topics as changing roles in water resource financing, federal versus state versus regional responsibilities, water importation or interpasin transfer issues. and state and regional groundwater manage-

For preliminary program and registration information, contact Kenneth D. Reid, Exec utive Director, AWRA, Suite 220, 5410 Grosvenor Lane, Bethesda, MD 20814.

ment issues.

# Call for Papers

Abstracts must be received in the AGU office by 5:00 P.M. on September 14. Late abstracts (1) may be summarlly rejected by program chairman, (2) may not be published in advance of the meeting, or (3) if accepted, will be charged a \$25 late fee in addition to the regular publication charge.

September 14

The 1983 Fall Meeting of the American Geophysical Union will be held in San Francisco from December 5-10 at the Cathedral Hill and Holiday Inn/Coklen Gateway hotels. Blocks of rooms are being held at the Cathedraf Hill, the Holiday Inn/Golden Gateway, the San Franciscan, the Holiday Inn/Gieje Center, and the Groscenor Inn. Corregonding authors will be sent logisting and registration forms. In addition, the forms will be published in En.

### General Regulations

Alestracts may be rejected without consideration of their tometti if they are not received by the deadline or are not in the proper format. Abstracts may also be rejected if they contain material outside the scope of AGU activities or if they contain material already published or presented elsewhere. Only one contributed paper by the same first author will be considered for presentation; additional papers (unless invited) will be automatically rejected.

Only AGU members may submit an abstract. The abstract of a nonmember must be accompanied by a membership application form (with payment) or it must be sponsored by an AGU member.

There is a publication charge of \$40 \$30 if prepaid) for each abstract. If the first author is a student, the publication charge is \$20. Both invited and contributed papers are subject to the publication charge. Prepayment of the publication charge can save money. Send a check for \$30 (\$15 for students) with your abstract. The abstract must be received at AGU by September 14 to avoid an additional

\$2ā charge. AGU will acknowledge receipt of all abstracts. Notification of acceptance and scheduling information will be mailed to corresponding authors in late October.

### Abstracts

The abstract page is dicided into two parts: the abstract itself and the submittal information. Follow the instructions for both carefully. Please use a carbon ribbon to type the material, and do not exceed the maximum rli-Abstracts that exceed the noted size llinitations will be trimmed to conform.

The meeting program will be prepared by photographing the abstracts exactly as they are received. Use the mridel abstract to prepare the final version. Submission of an abstract for an AGU meeting is presumed in carry with it permission for AGU to reproduce the abstract in all editions of Eos and in the programs and reports relating to the meeting. It is also presumed to permit the free copying of those papers. Although Em is n copyrighted journal, authors are not requested to transfer copyright. Copyright, where it exists, will be reserved by the nu-

### Submittal Information

Numbers refer to the items in the submittal block on the sample abstract.

1. Title of meeting.
2. Identification (only members may stibmlt on abstract; this includes invited authors): Type Identification number of one member author (LD number is the line consisting uf four letter's followed by the six digits; see member's mailing label on Ess or journals), or, if no author is an AGU member, type the ID number of the member aponsor (sponsor's

name must also appear on the abstract at the end of the author portion). If no 1D number is given, a membership application and dues payment iniisi accompany the abstract. Call AGU (800-424-2488 or 462-6903 if you are in the Washington, D.C., area) immediately if

you need an application. 3. Corresponding address: Gice complete address and phone number of author to whom all correspondence (acknowledgment and acceptance letters) should be sent. Abbre-

ciate us much as possible.

4. Section of AGU to which abstract is submitted luse the following letter abbreciations): A (Atmospheric Sciences); G (Gendesy); GP (Geomagneosm and Paleomagnetism); H [Hydrology); O (Ocean Sciences); P (Planetology); S (Seismology); SA (Aeronomy); SM (Magnetospheric Physics); SC (Cosnic Rays); SS (Solar and Interplanetary Physics) ics): T (Tectonoidrysics); V (Volcanology,

Geochemistry, and Petrology); U [Union). 5. Type title of special session (if any) to which submittal is marle.

6. Indicate your preference for a particular kind of presentation by one of the following letters: O, oral; P, poster. The chairman may assign you to either of these types of

presentation in order to fit his program plan.
7. Percent of material previously presented or published, and where. 8. Billing information:

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(c) If a student member is the first anthor, the student publication rate is applica-Indicate that the student rate is applica-

(d) If prepaid, enter amount enclosed.

9. Indicate whether paper is C [contributed] or I (invited). If invited, list name of in-

### Poster Sessions

A large, centrally located meeting room will he set up for poster presentations. Experience from recent AGU meetings and from other stientilic societies has shown that a poster presentation, while more tlentanding of the author, can provide a superb upportu nity for comprehensive discussions of research results. Some sections are organizing poster sessions on specific topics, and contributed papers on these subjects will automatically be scheduled as posters. In other sections it may be necessary to assign papers to poster sessions even though the authors requested oral presentation.

Presenters of poster papers are reminded that a poster exhibit requires careful preparation. Figures and text will be scrittinized in detail, antl authors must be prepared to tliscuss the contents of their papers in depth. Under these conditions, well-prepared figures and concise logical text are essendal.

### **Program Committee**

Meeting Choirman H. Frank Eden. NSF heric Sciences (A) Ronald Taylor, NSF Geodesy (G) William Sjogren, Jet Propulsion

Geomognetism and Paleomognetism (GP) Subir K. Banerjee, University of Minnesota Hydrology (H) Dennis P. Lettenmaier, Unlversity of Washington, Scattle

Ocean Sciences (O) Dave Cutchin, Scripps Institution of Oceanography
Planetology (P) Richard J. Terrile, Jet Pro-

pulsion Laboratory
Seismology (S) Robert J. Geller, Stanford SPR Aeronomy (SA) Raymond G. Roble,

NCAR SPR Cosmic Roys and Solar and Interplonetar Physics (SS/SC) Miriam A. Forman, SUNY,

Stony Brook SPR Cosmic Rays and Solar and Interplanetary Physics (SSISC) Bruce T. Tsurmani, Jet usion Laborator

SPR Magnetospheric Plessics (SM) Michael Schulz, Aerospace Corp.
Tectonophysics (T) Raymond F. Jeaninz, Unicersity of California, Berkeley

Volcanology, Geochemistry, and Petrology

(V) Peter W. Lipman, USGS

### Special Sessions

Polar Research

Geomognetism and Pulcomognetism (GP) Applications of Paleomagnetism to Tectonics of the Western United States

Electrical Conductivity of the Crust and Up-per Mantle—Field Methods and Laboratory easurements (in cooperation with the Committee on Mineral Physics)

Problem Solving With Rock Magnetic Tech-niques—Case Histories

Hydrology (H) Glacier-Ocean Interactions (jointly sponsored with Ocean Sciences)

with Ocean Sciences)
Instream Flow Requirements for Fish: Methodologies, Implementation, and Impacts
Multivariate Modeling of Hydrologic and
Other Geophysical Time Series
Searching for More Physically Based Extreme
Value Distribution in Hydrology

Statistical Procedures for Estimation of Flood Risk at Gauged Sites

Symposium on Optimization Techniques for Managing Groundwater and Stream-Appli-Fee Systems The Origon and the Amazon-Hydrobyy.

Sedimentology, Genchemistry, and Favilogy of Large Tropical Rivers Transport Processes of Excessive Schiment Loads

Treatment of Ecapotranspiration, Soil Moisture Evolution, and Aquifer Recharge in Watershed Models Water Quality Analysis of Impoundments

Chemical Tracers and Global Circulation Modeling Diagenesis in Deep Sea Drilling Cores El Niño of 1982-83 Geochemistry of Estuaries Geochemistry of Hydrothermal Phones in Viclnity of Mid-Ocean Rirlges

Ocean Sciences (O)

California Current

Parts of Ocean Busins

Ocean-Glacier Interactions (jointly with Hydrology) Rossby Waves and Eddies in the Eastern

Sedimentation Patterns in Tectorics in Actice Continental Margins (jointly sponsored with Tectonophysics) Sub-Sealed Disposal of Nuclear Wastes: Site

The Response of the Upper Ocean to Veri

Evolution of Oceanic Lithosphere (cosponsored by Tectonophysics and Volcanology. Geochemistry, and Petrology Rio Grande Rift (cosponsored by Teconophysics and Volcanology, Genchemistry,

and Petrology) Lateral Heierogenesis in the Mantle Tomograph

SPR: Aeronomy (SA) **EUV-VU Airglow** Lower Thermosphere-Upper Mesosphere

SPR-Cosmic Raye (SC) IMP 7 & 8: Correlative Studies Over the Sular Cycle, Including Correlative Studies With Other Spacecraft and/or With

Ground Data (poster session) (cosponsored by SPR: Interplanetary Physics and SPR: lagnetospheric Physics) IMP 7 & 8: (cosponsored by SPR: Interplanetary Physics and SPR: Magnetospheric

SPR-Magnetospheric Physics (SM) Aurora and Substorms (poster session) Comparatice Planetary Magnetospheres and Comparative Auroral Phenomena Geomagnetic Tail and Boundary Layer (post-

Magnetospheric Currents and Fields [poster Numerical Simulation of Space Plasons (100st-

Special Call for Papers on all Subjects Waces, Instabilities, and Turbulence in Space

Plasmas (poster session)

SPR-Solar and Interplanetary Physics (SS) AMPTE Theory and Predictions Solar Wind Interactions With Comets, Venns, anrl Titau

Active Tectonics Franciscan Geology of the San Francisco Bay Area: The Nanoplate Tectonics of the

AGU Fall Meeting Site Tectonics and Sedimentation in Active Continental Margins (jointly sponsorerl by Ocean Sciences)

Volconology, Geochemistry, and Petrology (V) Calderas and Associated Volcanic Rocks |Krakatao Centennial) scades Volcanism and Implications for

Geothermal Resources Ocean-Ridge Basaltic Volcanism (Laki Bicen-

Structure and Dynamics of Hawaiian Volca-

### Other Special Sessions

Mineral Physics
If one of the following fields is covered in the broadest sense, regardless of the section to which your paper is submitted, please add on your abstract "For Mineral Physics Session" untler number 5 of the submittal information: (1) physical measurements on minerals, (2) calorimetry, (3) high-pressure mineralogy, (4) defect structure stutlies, (5) mineral and solids equations of state, (6) quantum mechanics of solids, (7) spectral mineralogy, or (8) electrical measurements on minerals.

### Session Highlights

Geodesy will be hosting special sessions this fall on the results from the earth-orbiting satellite LAGEOS [Lasen Geodynamics Satellite). Summarles will be presented by the major in-

tees, mass and gravity field of the earth, rional information can be obtained from J. D. evolution, and geophysical interpretation. There will also be sessions decored to on Salas (telephone: 903-491-8460 or 303-491dynamics, gravity data analysis, modeling tidal effects, timing, and precision orbid

Hydrology (11) Calarier-Chean Interactions (jointly posso hy Hydrabogy)

A special session on glacier-oceanings tions will be convened jointly by the Ocea Sciences and Hydrobige sections, Papers solicited that address topics on the interes processes between glaciers or glacial ice in aceaute environment. Topics of interesting rhole but are not limited to calcing of ide ter glariers, thermodynamic interaction be tween martine ice shelves or icebergs and scaluem occania modification, and iceles drift. Inched papers will give overview cent studies and new decelopments in the area. Abstracts, in standard AGU forms, should be submitted in later than August to either of the session cochairmen: Auto G. Formtoo, Project Office—Glaciolog, St 85tt, USGS, 1201 Pacilic Acenue, Tacom. WA 98402, or Erleyard G. Juscherger, 05 Unicersity of Poget Sound, Tacona, WA 98-116. In addition, send the original and copies of the alestruct to Fall Meeting, M 2000 Florida Acemie, N.W., Washington,

Instream Flow Requirements for fuh: Meb odologies, Implementation, and Impas

Recent Terleval and state legislation has guaranteed that fish production must be to sirlered in the decelopment of water resources. This renewed interest in fish maagement will affect significantly, in many ations, the amount of water available for consumptice water uses. Numerous tedeniques have been suggested for establishing instream flow requirements, ranging from Indraulic models for streamlow to fish be no models. Less research has been directed toward other significant issues of insteam flow maintenance such as ecalitation of the ecotomic impacts of these instream requir ments on other users, their economic box lits, and flore estimation techniques that in cate the frequency with which these require ments affect other users.

Papers are solb hed that explore techniq used to establish instream flow requirem the economic and physical interactions of the requirements attorng water users, and prothree that incorporate low flow frequency timates into requirement analysis. Papers) dressing the conceptual framework for 183 lishing instream flow requirements, mold calibration and verification, case sudies, and related topics are also welcome. Abstract, # stantland AGU format, should be searby A gust 31 to Richard Palmer, Department of Civil Engineering, FX-10, University of Wushington, Scuttle, WA 98195, In add sentl the original and two copies of the ab struct to Fall Meeting, AGU, 2000 Florida enne, N.W., Washingont, DC 20009.

### Multivarine Modeling of Hydrologic and Other Geophysical Time Series

This special session is sponsored by the Surface Runoff Committee of the Hydroks section. The purpose of this special senior to bring together individuals from differn disciplines to thiscuss the state of the artial new developments of stochastic description and/or utradeling in time and/or in spaced multiple time series of hydrologic and geo physical phenumena.

Quite a number of models and modeling techniques have been proposed for representing univariate and multivariate time st ries with applications in hydrology and go-physics. However, even when modeling time series there are still a number of unit sulved or controversial questions that neri further studies and discussions. This studies is compounded when dealing with multiple time series. As the models attempt to into porate more statistical features of the bear cal time series, the number of paramet creases, the mathematics of the model be comes cumhersome, the identification and estimation procedures are more difficult. testing of goodness of fit of the models is more complex, and the problem of how to deal with various types of uncertainties of the property of the proper

Possible topics for this special session clude multivariate model identification ich niques, parameter estimation protedures, crete and continuous models, ARMA and non-ARMA models, Gaussiad and non-line model testing and validation tec ian models, models with periodic and not ian models, models with periodic and periodic parameters, aggregation and dispersion techniques, sensitivity analysis modeling of uncertainties. Bayesian and periodic parameters, models for transition information, models for detection of dispersion models for data generation and longer and models for data generation and longer and models for data generation and longer and longer and models for data generation and longer and l

Abstracts, in standard AGU format should be sent by August 15 to Jose D. Salas, Department of Givil Engineering, Colorado State University, Fort Collins, CO. 80528. In after tion, send the original and two copies of the abstract to Fall Meeting, AGU, 2000 Forth Avenue, N.W. Washington, DC 20009, Additional Collins of the Avenue, N.W. Washington, DC 20009, Additional Collins of the Avenue, N.W. Washington, DC 20009, Additional Collins of the Avenue, N.W. Washington, DC 20009, Additional Collins of the Collins of vesilgators dealing with entity rotation, station abstract to Fall Meeting, ACU 2000, A coordinares and baselines; ocean tide parame. Avenue, N.W., Washington, DC 20009, A

to measure future changes.

Searching for More Physically Bused Extreme Value Distribution in Hydrology

There is a great need in hydrology for ex-treme value distributions that incorporate more of the physics of the unrierlying processes. For floods, this will allow the hydrologist to make better rise of the scarce diffi which is usually available for stream)lows and to attack the problem of imganged catchments with a better approach than regional A special afternoon session will be itedicated to this problem. The topics to be covered will be scale and similarity in flood frequency

response, derived distributions for ungauged calchments, inhibition phenomena of thiori A romparison session in the afternoon will discuss the most recent statistical techniques for estimating flood risk. A panel discussion daired by John Schaake will follow the afternoon session in which new avenues of reearch on both areas of floorl estimation will

Both sessions are under the auspices of the Surface Runoff Contmittee of the Hydrology ection. For more information on this session please contart Juan B. Valdes, Room 48-331. Massachuseus Institute of Technology, Camnidge, MA 02139 (telephone: 617-253-2) 17). The original of the abstract and two copies, in standard AGU format, should be sent to Fall Meeting, AGU, 2000 Florida Acenue. N.W., Washington, DC 20009.

Statistical Procedures for Estimation of Flood Risk at Gauged Sites

During the last 5 years, research has produced many new and improved statistical techniques for estimating flood risk and variou qualities of the flood-floor distribution at gauged sites. This session will review these new ideas and Bulletin 17 as revised in September 1981. Topics should include adout tages of regionalization, regional skewness, empirical Bayes estimators, probability weighted moments and the Wakeby distribution, recasurement error and its impact, nonparametric procertures, and the use of historkal flooding information. A compatition session in the afternoon will examine the warch for more physically hased extreme val-ue models in hydrology. The day will close with a special panel discussion cliniced by John Schaoke, Jr. Abstracts, in shutdard AGU farmat, should be sent by August 15 to Jery & Stedinger, Hollister Hall, Cornell Universith lthaca, NY 14853. In addition, send the original and two copies of the abstract to Fall ng, AGU, 2060 Floritla Avenue, N.W., Washington, DC 20009.

Simposium on Optimization Techniques for Managing Groundwater and Stream-Aqui-

Goundwater has been a largely unmanaged resource. Consequently, many areas are acountering problems of excessive local drawdown, reduced streamflows, and groundwater contamination. Currently, groundwater simulation models are used to ore management ulternatives to solve these problems, in the future, combined use of groundwater simulation and optimization techniques of mathematical programing may prove to be a tremendous aid to managing groundwater resources. Such management models may be used to manage aquifer pumping and injection systems, to optimally allocate water in a stream-aquifer system, to manage groundwater quality, or to inspect the influence of institutions upon patterns of

regional groundwater use. This symposium on optimization techniques in groundwater management is sponsored by the Groundwater Committee. Abstracts, in standard AGU formot, should be sen by August 31 to Steven M. Gorelick, U.S. Geological Survey, Mail Stop 21, 345 Middlefield Road, Menlo Park, CA 94025. In addition tion, send the original and two copies of the abstract to Fall Meeting, AGU, 2000 Florida Avenue, N.W., Washington, DC 20009. More information can be obtained by contacting Steven M. Committed the August 115, 202, 2111 Sieven M. Gorelick (telephone: 415-323-8111 ext. 2[4]) or Manoutch Heidari, Kansas Geological 3urvey, Lawrence, Kansas (telephone: 913-864-5672).

The Orinoco and the Antazon: Hydrology, Sedimentology, Geochemistry, and Ecology of Large Tropical Rivers

Significant proportions of the Orinoco and nazon basins are likely to be modified drastically during the next several decades by human activities. Deforestation, hydroelectric and other water-resources developments, and pollution from pulpwood processing, mining, leavy industries, and refineries will change the nature of the river flows, the solid and solved materials they transport, and the sological communities they sustain.

Not much is known about these two rivers: A few long records of river stage exist, but thream-gauging programs were initiated less than 20 years ago, so streamflow records are shon and very few data are available on the discharms of the data are available on the discharge of dissolved and solld materials.

Systematic studies of organic transport, nument cycling, and biological activities of these ricers were undectaken only recently. These short records and the results of recent or ongoing studies constitute the only hasis for connenting the characteristics of these rivers under nearly undisturbed natural conditions and serve as baseline data against which

This program is organized to focus attention on scientific studies presently underway on the Rio Orinoco and the Rio Amazonas, A one-half day session of invited papers will be followed by sessions of contributed papers sponsored jointly by the Hyrlfology and Ocean Sciences sections. Anyone conflicting studies on these overs or on the coastal regions influenced by their flows is invited to submit an abstract of the results of the research for consideration in the program. Abscracts, in standard AGU format, should be sem by August 15 to Carl F. Nordin, Jr., U.S. Geological Survey, Box 25046, MS 413, Denver Federal Center, Lakewood, CO 80225 (telephone: commercial, 303-234-2320; FTS. 234-2320). In addition, send the original and two copies of the abstract to Fall Meeting, AGU, 2000 Florida Avenue, N.W., Washington, DC 20009.

Transport Processes of Excessive Sediment

Much sediment transport theory is based on law and moderate sediment concentrations and may not be applicable for excessing sediment loads. The Erosion and Sedimentation Committee of AGU is sponsoring a symposium to review the state of the art for excessice sediment loads.

Some of the subjects already accepted for presentation include a comparison between research on hyper-concentrate sediment loads in the People's Republic of China and the United States, excessive sediment loads during the Mount St. Helens episode, pipeline transport of slurges, and an ocerview of the American Society of Civil Engineers Task Force on the effects of high sediment concentrations on velocity profiles and transport. Submission of additional papers dealing

with the general area of transport processes of excessive sediment loads is encouraged. Abstracts, in standard AGU format, should be sent by August 15 to Walter F. Megahan. Forestry Sciences Enboratory, 316 East Mettle Street, Boise, 1D 83702 (telephone: commercial, 208-334-1457; FfS, 354-1457). In addition, send the original and two copies of the abstruct to Fall Meeting, AGU, 2000 Florida Aremic, N.W., Washington, DC 20009.

Papers presented at this session may also be published in Woler Resources Research. Speakers who would like to bace their papers considered for publication should provide a rompleted manuscript to Walter F. Megalian at the time of the meeting.

Watershed Models

The session's incited and contributed papers will explore the manner in which the hydrologic phenomena of ecapotranspiration, soil moisture ecolution (including inter)low). aquifer recharge, and aquifer return flows are treated in current (small) watershed and/ or river basin models. Papers addressing the Physical or conceptual basis for the treatmen of the hydrologic components, the rientifed structure of the mathematical models, the calidity of the approaches taken, the case of calibration of the subsurface parameters, the experience in use of the models, etc., are welcome. Abstracts, in standard AGU formit. should be sent by July 29 to H. J. Morel-Seytonx, Department of Civil Engineering, Colorado State University, Fort Collins, CO 80523 Itelephone: 303-491-5448 or 303-491-85491. In addition, sent the original and two copies of the abstract to Fall Meeting, AGU, 2000 Florida Avenue, N.W., Washington, DC

A session will be deroted to the analysis of vater quality in imparundments and ricer-ruo lakes. Among the topics of interest will be (1) mathematical modeling of reservoir water quality, including entroplecation, basterial pollution, and toxic contamination; (2) the role of suspended colids in determining the water quality of impoundments and river-run lakes: (3) characterization of diffusion and dispersion in impoundments; and (4) the def-

Other topics related to aspects of water quality peculiar to importedments and rivertuit sydems the contrast to natural lakest wil ilsa be considered.

SPR: Interplanetary Physics (SS) AMPTE Theory and Predictions The Solac and Interplanetary Physics and the Magnetuspheric Physics sections are co-

reatment of Evapotranspiration, Soil Moisture Ecolution, and Aquifer Recharge in

Varer Quality Analysis of Ingroundments

inition of entrophication for tesercoirs.

Abstracts, in standard AGC formar, should be sent lu August 15 to Steven C. Chapra. vironmental Engineering Division, Civil Engineering Department, Texas A&M University, Gallege Station, TX 77843. In ablition, send the original and two copies of the abstract to Fall Meeting, AGU, 2000 Florida Avenue, N.W., Washington, DG 20009.

sponsoring this all-day special session. The purpose of the session is to increase awareness of the AMPTE science objectives and to expand the base of relevant theoretical work n anticipation of the lanneh of the Actice Magnetospheric Particle Tracer Explorers mission in August 1984. (For more informa-

tion on this mission, see Krimigis et al., Est, p. 843, November 9, 1982.) Invited speakers will discuss the interaction of large plasma celeases with the solar wind and the transport of ions through the magnetosheath, the magnetonause, and within the magnetosphere. Contributed papers are solicited, particularly in the areas of bin transport through the bow shock, magneropinise entry, magnetospheric transport, and wave excitation in mixed hotcold plasmas. Papers presented at this session may also be published in the Journal of Geophysical Research. For additional information, please contact S. M. Krimigis Itelephone: 301 953-7100). Abstracts should be directed to the SPR:SC/SS section and should clearly indicate that they are fin this session. Please send the original and two copies of the abstract to Fall Meeting, AGU, 2000 Florida Avenue, N.W., Washington, DC 20000.

Tectonophysics (T)

Tectonics and Sedimentation in Active Contidental Margins (jointly spansored by Orean

This special session, jointly sponsored by the Ocean Sciences and Tertonophysics sec-tions, will focus on new work dealing with the role of sedimentation processes in response to necondes in active margins. Correlation of depositional systems to recomics, diagenetic cleanges in response to tectotic processes. sediment stability in active magins and their causes, sediment deformation during deposition, and regional patterns of sedimen ration are some of the topics to be included in this session. Abstracts, in standard AGU lormat, should be sent by September 14 to Gerage deV. Klein, University of Illinois at Urbana-Champaign, 245 Naonal History Boilding, 1301 W. Firren Surer, Urbana, H 61801-2099, In addition, send the original and two condes of the abstract to Fall Meeting, AGU, 2000 Florida Avenne, N.W., Washington, DC 20009, For more information, contact George rieV. Klein (telephone: 217-333-2076).

Meetings trust on p. 434 t

### Sample Abstract

Technique for the Preparation of Abstracts

F. R. S. T. AUTHOR (School of Oceanography, Hydro University, Watertown, Mass. 02172) S. C. N. D. AUTHOR (USGS, Woods Hole, Mass. 02543) (Sponsor: I. C. Alvin)

Follow this example in typing the abstract. The printing plates will be prepared by photographing the abstracts exactly as they are received, except that abstracts exceeding the maximum length (18 cm) or width (11.8 cm) will be cut to conform.

Use a good typewriter with a ribbon in good condition. A carbon ribbon gives the best results. Please use type of about this size. Use 12 pitch. There will be a reduction of 50% for the printed abstract volume.

Follow these guidelines:

(1) Type title in capital and lower case letters except where all capitals are standard. Underscore entire title.

(2) Leave one line blank after title.

(3) Type names of authors in all capital letters, with affiliation and address in capital and lower case letters. Do not leave blank lines between authors. (4) Underscore the name of author who will

present paper. (5) If no author is an AGU member, type sponsor's name in capital and lower case letters.

(6) Leave one blank line after author block. (7) Neatly drawn in symbols or Greek letters are acceptable. Use India ink.

(8) Use SI units.

NOTE: There are no special forms distributed for typing abstracts. Please leave at least 4 cm between top edge of paper and abstract title. Type abstract as close as possible to left edge of paper.

### **Submittal Information**

(See axplanation)

1. Ps11 Meeting AUTH052536

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la). Corresponding address: S.C.N.D. Author MS 123

Woods Hole, MA 02543 |b). Telephone number 617-548-1234

O (Ocean Sciences) Special Session

(or none) 6. P (Poster)

10% at Midwest Meeting

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(o). Student rate applicable

|d|. If prepaid enter amount enclosed. (P.O.'s requiring involving are not aligible for discount rate)

9. C (Cootributed)

Abstract Deadline: September 14

Mail original and two copies to Fall Meeting

American Geophysical Union 2000 Florida Avenue, N.W. Washington, D.C. 20009

Volcanology, Geachemistry, and Petrology (1') Calderas and Associated Volcanic Rocks (Kcakatan Centenniah

The origin of calderas and their relation to nyroclastic volcanism was first brought into focus by the catastrophic eruption of Krakatau in 1883. One hundred years later, much work is concentrating on the history of cablera-lurning volcanic sequences, validera-culapse mechanisms, the internal gradure of calderas, and perrologic evolution of calderarelated igneous rocks. These and other topics of volcarric calderas will be the subject of a centennial symposium at the AGU Fall Meeting; contributions are welcome. Please send the original and two copies of the abstract to Fall Meeting, 2000 Florida Acenue, NAV., Washington, DC 20009. For further information, contact the convenors: Stephen Scill, Department of Geology, University of Texas, Arlingtoo, TX 76019 (telephone: 817-273-2987); Grant Heiken, Geosciences Division, Los Alamos Scientilic Laboratory, Los Alainos, NM 87545 helephone: 505-667-8477): or Peter Lipman, U.S. Geological Survey, Box 25046, MS 913, Dencer, CO 89225 (telephone: 303.234.2901)

Cascade Volcanism and Implications for Gen-

The Cascarle colcanic are in the northwestern United States has been the target of intense multirlisciplinary geologic and geophysical study in recent years, with major feel on genthermal-resource potential and subanirhazard amplysis. This special session will provide both broad summary overviews of recent work and also report on new detailed studies. Convenins are Patrick Mulller, MS 90C, U.S. Geological Survey, 345 Middlelickl Road, Menhi Purk, CA 94025 (telephone: 415-323-8111, ext. 4151), and Wendell Duffield, U.S. Geological Survey, 2255 North Gemini Drive, Flagsraff, AZ 86001 (telephone: 102-765-7205). Send the original and two copies of the abstract to Fall Alceting, AGU, 2000 Florida Aceurie, N.W., Washington, DC 2000!!.

Ocean-Ridge Basaltic Volcanism (Laki Bio-

The ecuption of Laki volcano on beland in 1783 is the most viduationus basaltic empirion of the historic record-25 km3. This special session, 200 years later, will focus on petrologic and strutural featurer of ocean-ridge colcanism, both in Iceland and worldwide Especially timely would be to compare the subacrial and submarine morphologic fentures of 15ft-zone volcarium. For further information, contact Haraldar Sigurdsson, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI 02882 (telephone: 401-792-6596). Send the original and two copies of the abstract to Fall Meeting, AGU, 2000 Florida Avenue, NAV., Washington, DC 2000tt.

Structure and Dynamics of Hawaiian Volca-

Recent geologic, geophysical, and petrologic studies of Hawaiian colcanism, with special emphasis on the 1983 emption of Kilanea. For information, contact Robert Decker, U.S. Geological Survey, Hawaiian Volcano Obserratory, HI 96718 (telephone: 808-967-7328). Send the original and two copies of the abstract to Fall Meeting, AGU, 2000 Florida Acenue, N.W., Washington, DC 20009.

# Meeting Reports

# Valles Caldera Workshop

A Continental Scientific Drilling Project (CSDP) Wockshop, attended by 87 scientists, focusing on the Valles caldeca was liristed by the Department of Energy and the Los Alainos National Laboratory, un Octuber 5-7, 1982, in Los Alamos, New Mexico. The culdera, a large, Quaternary magnitudydrotherstem, hes at the intersection of the Rin Grande vift and the Jemez lineament in north-central New Mexico and is a prime site

for the first deep drill hales. One mujor objective of CSDP is to decelop a broad scientific understanding of the mots of an active hydrothermal system ussociated with recent igneous intrusion. Surface gen-logical, geophysical, geochemical, and hydro-logical data, along with information from shallow exploratory drillludes, will be used in the process of interactive development and testing of mustels and hypotheses for such systems. Ultimately, tleep drilling will be essential tes provide direct sampling of lluids and rocks at depth and to mensure illrecity the critical in sim physical parameters. Thus, deep drilling research becomes an integral and necessary component in the synthesis, re-finement, and verification of three-tilmensional models of hydrothermal-magina sys-

tems and processes. The Volles caldera was selected as an attractive site for deep drilling because (1) the regional and local geology, geophysics, and geochemistry have been well studied; (2) lithologic, geochemical, and thermal data have been obtained from many geothermal holes.

drilled to depths us great as 4.5 km; [3] liquid and possible vapor-dominated hydrothermal systems occur; and (4) geophysical anomalies suggest magma or interstitud melt at depth.

Key recommendations from this workshop include (1) the need for drilling several intermediate-depth holes [1000 m) prior to drilling a deep hole to enhance knowledge of the thermal regime at Valles, (2) the need for continuous coring in any CSD holes, and (3) the requirement to determine unequivocally whether magma exists beneath the caldera. The recommendations and the rationale for

### Geophysies Working Group

Participants in the Geophysics Working Group of the Valles Caldera Workshop considered two relat-

What is the evidence for interstitial melt under the Valles caldera? 2. What critical experiments should be per-

formed to determine the presence of melt under The discussion group felt that presently there is Insufficient evidence to say unequivocally that there is interstitial nich omler the caldera. However, evi-

clence iii hand supports the thesis that a melt zone might exist at relatively shallow depth | < 12 kml beneath the surface. reliminary geophysical evidence in support of

melt is exten Seismic analysis based on chemical explosions deionated near Farmington, N.M., shows both S wave and amplitude attenuation as well as P wave delays and telerismic frequency changes suggesting

anomalies beneath the califera. 2. The lack of earthquakes under the caklera in comparison with an otherwise higher regional seis-michy is evidence for a change in material behavior a the rocks below the caldera.

3. An apper crustal seismic transmission anomaly exists under the resurgent donte in the caldera.

4. Gerhard Suhr's miderustal seismb analysis

5. An electrical conductor exists at 10-12 km below the caldera and is compled with a regional elec-

The caldera rests on an area of very high heat

The temperature gradient analyses of Swanberg suggest a magniatic lieat source.

8. The gravity onalyses of Cordell, Seager, and

Wilt suggest an attornally. The very high temperatures (320°C) at the base of the HDR Fenton Hill holes and the direction of the measured gradients suggest a major heat source. Perhaps the most compelling evidence comcerus the recentness and long history of volcanism logether with geological arguments, and thermal

The Working Group felt that future geophysical work should concentrate first on completion of the reconnaissance investigations rurrent, then initiate high resolution geophysical research concentrating on the upper 10 km of the crust. This high resolution phase of research should focus on six topics

 Intermediate-depth drilling. Several inter-nediate-depth holes should be drilled in and around Valles caldera to obtain additional thermal

gradient measurements to be used for understanding the thermal regime in thermal modeling. Cores ould be obtained from the holes to aid in relining the geology, bloles should be logged to obtain other physical properties useful in modeling toge, density

9. Thermal modeling. Additional detailed thermal modeling using all available geologic and gro-physical constraints is needed. Modeling should endeavor to determine the vertical extent of the upper rothermal convective system and usufel the deep crustal thermal regime

Scismic research. Adultional seismic studies should be designed to focus on the three-dimensional structure of the upper 10 km of the crust

near the caldera. 4. Electromagnetic research. High spatial resolimon electromagnetic studies are needed to delin-cate the Crustal conductive anomalies in an eltory by

map the known near-surface hydrothermal system and the suspected deeper regions of metr.

5. Gravity modeling. Detailed gravity modeling using all available geologic and geophysical constraints is necessary to strip the effects of the Phanerozoic cover and facilitate modeling of the deep crustal structure beneath the caldera. Such modeling may yield additional bounds on the suspected licic magnia body.

6. Downhole geophysical sensors. A variety of downhole geophysical high temperature acusors thould be developed to be used in available holes. and results should be coupled to surface gentalical al

### Geochemistry Working Group

The question addressed by the Geothemistry Working Group was, What is the nature of the he rnial systems ereated when a silicic magnitude body is emplaced beneath the Valles caldera? To answer this question, data must be collected that al fine the hydrothermal systems with respect to third clieinistry, geometry, and solid phase composition. Stated another way, What processes produce the various systems associated with the Valles cablera?

To pursue these data, we recommend drilling live exploratory holes 1000 in deep [see Figure 1] to earn more about the nature of these lightfullerthal systems: their recharge, discharge, permeability, and associated phase clientstry. Specifically, we want to learn more about the following points immbers refer to the numbers in Figure 1).

1. The thermal regime in the southwest ringfracture zone to detecmine if it is a discharge zone and to discover more about differences in linkly and alteration phase assemblages in ignimization, carbon-ate, and the Precambrian rocks. This hole could be located near the youngest moat rhyolites in the caldera and thus satisfy one objective of the tieningy

Working Group.
2. The intersection of the northeast tracture one and the central gradien faults to determine if this area is a recharge zone for the deep system. 3. The nature and degree of communication, insluding wall rock alteration, between the suspected

vapor dominated zone and deeper hydrodurmal systems in the Sulphur Springs area. Indications are that the boundary between these zones moved flow 4. The northeast extension of the hydrothermal

system into the Jaramillo Ureek area along the central graben laulis. Our objective for a deep hole is to study a con-

իր re sedurior of mermor bin escut III Փ ed a calon spannency system may declet promal system with assurance reclarate and my mmeralization, and (3) depth to and posity heat source. With the data available non-took tion of hole 3 will lead to investigation of day metamos plus sestems extending into the Barr an and will define their competing mount neuncally with the shallower hydrothema. Has objective supports the Drilling Technology Working Linusp recommendation to tore or musty to the depth desired. Hole 3 presents oppio unity to study completely the mechanic infiltration metasomatism (finid composition) fransport as well as afteration assembliges and desper more diffusionally controlled melase and their ultimate relation to the deepling Geology Working Group

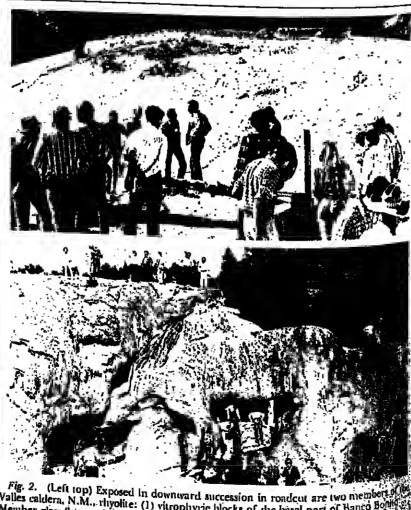
CSDP may provide the first sampling of man plumur behavailt a calibrat complex. From the poer tive of gerdogy, these samples will add tole awledge of unigonatic and crossal column mints describe the need for general and reject studies, values of deep sampling, need foreign ples, and a choice for the deep-drilling looks within the Valles califera.

1. We need a synthesis report on raiders of and hic regional geologic studies, diaximum a tile value of CSDP will occur only if resulted? drilling can be interpreted aslequately. Interpr tion requires knowledge of the regional geologic ting for deep drill holes and an adequae pole-model based on studies of comparable localists deep sampling of magnua-bydrothermal gasus an active caldera complex, the predictive mod moss be based on other active calders and an't sil" ablera complexes expused by crosion The an execusive literature un both active and fool dera-genthermal systems, but air adequate corp tensive summary of these systems is facting & portabl first goal for this phase of CSDP must the preparation of such a summary, if the Vila caldera is a drilling target, its deeper feature should be auticipated in terms of other "type of ra systems. The summary document may are pasis for selecting the best CSDP location for so of an active hydrothermal system.

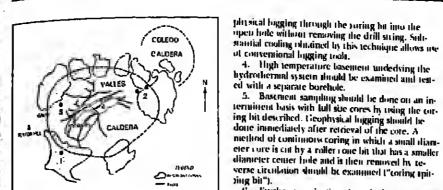
harlier research our well-exposed fossileaker terns is an important basis for extending these tille, value of USDP and a reoug argument for drilling in an active caldera system. Mineralmiaherarion, and thermal auteole development nost active in the last stages of caldera magnet luniour. Ohler exhaused califera systems are on printed by these terminal events. Deep diffeg a active califera system may clarify an ignerate thermal history that might then be extrapolate economically important calderas worldwide

For the Valley caldera, the relevant geologic framework includes Precambrian rocks of the mienter Uplila to the west, overlying Paleoroics in the cast that aid in understanding develops of the Rio Liranule with its associated drpo-

2. We need deep samples from an active at system. The expense and e)fort of deep drile; be bear repaid if drilling is designed to employ understanding of grobogy at depth. In Valence ru, there is knowledge from drilling at Fence !



Valles caldera, N.M., rhyolite: (1) vitrophyric blocks of the basal part of Banco Bondo S. Member glass flow and (2) well-bedded punice and ash of El Cajete Member. Characteristics of the base of the uppermost ash beil in the El Cajete section give an age of years B.P.; the overlying Banco Bonito Member is about 0.05 Myr okl. (Top right botter) Participants of the Valles Caldera Workshop examine rulns of the Sudphut Spites sort in New Mexico, where tourists baths in material from het applies and mud polessia. left) Participants of the Valles Caldera Workshop examine rulns of the Sidphur Spring sort in New Mexico, where tourists bathe in waters from hot springs and mud polyety of thermal features occurs furnaroles, hot aprings, mud pots, and gaseous cold springs. So, concentration may be as high as 8,000 mg/l. Data suggest that hot gases are in the aprings high as 8,000 mg/l. Data suggest that hot gases are in the springs, N.M. The travertine dam was deposited by thermal waters that discharge is strand of the Jemez dam was deposited by thermal waters that discharge is and B are practically identical to those from the deep fluid within Valles caldera.



4. High temperature basement underlying th

L'eriain measurements require that tools be at in titu temperature. Substantial technical develop-ment is required if temperatures exceed \$00°C.

8. Further development work on high-tempera-ture drilling flolds, corresion inhibitors, and hist-cir-

culation materials will aid deep strilling operations.

9. Examination should be given to high tent-

dapt them to existing high-performance toller-

three wear on the drill string.

10. Use of existing wellbores would aid technical developments. Wellbores exist at the Fernon-Hill

IDR site and at the Union Geothermal Baca site.

Plenary session chairmen were John Whet-

up chairmen included Jamie Gardner, Da-

Goff, John Rowley, and Robert Potter. The

sie Energy Sciences of the U.S. Department

workshop was sponsored by the Office of Ba-

This meeting report was prepared by Robert E. Riecker of Los Alamos Scientific Laboratory, Los

HDR Geothermal

Hor devices (HDR) is defined as that part

of a geotheroial anomaly where the thirds

needed for production of steam or hot water

are lacking. Most of the world's geothernal

resource is not present in the form of natural

hydrothermal systems but as HDR, Develop-

manufade geothermal systems is in progress

in several countries. The largest of these ex-

periments, the Feston Hill FLDR geothermal

project, is fumled by the U.S. Department of

Energy and the governments of West Germa-

ny and Japan. This project is located a short

distance west of the rim of the Valles Caldera

in the Jemez Mountains of New Mexico, As

the Fenton Hill experiments progressed, it

became evident that the location and extent

cas should be evaluated and that potential

HDR drilling sites be located as part of a

comprehensive program needed to encour-

age its development. Because the HDR re-

source lacks the sharp physical and chemical

cuntrasts produced by natural fluids, it pre-

sents different exploration problems from those of conventional hydrothermal explora-

tion. The purpose of a workshop, held in Los

Alamos, New Mexico, June 21-23, 1982, was

to review geological, geochemical, and geo-

physical exploration methods currently used

for HDR recognition and resource evaluation

and to evaluate new Ideas for HDR explora-

Heat flow, because it involves direct tem-

mate standard for evaluating geothermal po-

perature measurements, is usually the ulti-

of resolution parrows to that of choosing

Heat Flow Criteria

drilling sites.

of the HDR geothermal resource in other ar-

ment of this resource through the use of

Exploration

one bits. Such develor

Acknowledgments

Alamos, NM 87545

perature turbulrill systems and in methods that

Fig. 1. Detailed map shows approxinae surface outlior of Valles cable a and esurgent domes. Numbers refer to sugested locations of intermediate-slepth oles suggested by the Geochemistry Working Group Inot necessarily codorsed by the wurkshop! See text for complete

heralders and from drilling in the resurgent donne within the raldera. Depths of 4.4 km and tenuserarates of ~350°C were reached. Ontllow ruffs, calife 12 fill older Cenozoic volcanic rocks, Cenozoic amb Paleozoic sedimicuts, and Precambrian basenicus were sampled. Conventional drilling yields much i formation; the underlying photon margor remains submittee. Features of the intrusive anteole are to-

ten and Grant Heiken. Fraser Golf and Sic-Down-hole geophysical studies and strest-relaxphen Bolivar were lield trip leaders. Working alon research can be made on oriented core. Detailed sampling toust be a major goal of CSDP. vid Vaniman, Mark Amler, Rubert Riecker, William Linghlin, Robert Charles, Fraser

3. We must collect deep core samples. Collection of deep samples many be a major goal of CSDP. Carrendy available sampling technology should be used extensively early in the CSDP drilling schedde Cared exploratory holes will answer many upres-tion about intra-caldera takebed and volcaniclastic araigraphy, detailed magnetostratigraphy the Valles calders already provided the type locality for the brief Jarantillo event), and Centronic rectionist Greater emphasis, however, must be on adequate deep sampling, where the greatest rewards lie. An overall geologic goal of CSDP must be collection to these unique, deep samples. Preliminary explor-ates driffholes can be cored throughout, but the proback from deep holes will be best by drilling to depth as rapidly as possible and then concentrating

4. Siting of CSDP deep holes: A geologic per-

the based on Vallet califera. The value of USDP reputilling is based on exploration of deep geofeatures. Ability to reach deep magnin-relate haures, in particular the pluton margin, most be the major emphasis. One criterion that might help to sie a deep hole is occurrent e of the voyingest voland centers. The young most-zone silicit donnes of he Valles caldern are appealing targets for drilling realities. Besides drilling near the most recent countre pathways, a locality creat one of these soung domes will help to investigate deep features long the ring fracture that brouds califera collapse. ach fracture systems can be seen in older, disse ed calderas to be major pathways for hydrotherma eration and mineralization. Drilling "inhuard" o ring fracture near one of the young dicie dones could provide a sample of active processes along this wild fracture system. The location of this bok tould saisly the drilling objectives of the Geo-themistry Working Group. As a secund princity, au-other deep hole "outbroard" of the ring fracture sys-tem would provide samples from a nearby but relaneh stable section of volcanic oleponits and country not. Drilling near one of the youngest allicic flomes will be a favorable locality in the Valles calders from value for CSDP and also because of the existing data base for arens outside the western raidera rin enton Hill and in the resurgent donne | Union

### hilling Technology Working Group

Oils geothermal drilling program).

Esting drilling technology is adequate to drill orcholes in the Valles Caldera to temperatures of 500°C. This judgement was reached after reviewing specience gained in development of the Union Confermal Baca site and the Los Alamos National Laboratory Fentoo Hill HDR site. This experience torered all aspects of drilling in volcanic, sedimentally, and crystalline basement rocks and at substantial peratures [~340°C) and deputs (~4570 m). Continued drilling into deep basement followin operations needed to study the shallower hydro al sitem would be both difficult and costly. We mend drilling separate holes to investigate

each of the two thermal regimes. Drilling experience Indicates str are inadequate and that coring, either total or intermittent, is required. A coring bit developed for the IDR project may allow both reasonable drilling rates and ability to core continuously, especially in the redimensary agreement. sedimentary sections. Of particular interest is the lymbiosis that could be developed between cor ag and downhole measurements. After core is takand retrieved, the bit is pulled back some chosen digance, and a sequence of logging tools is run through recently cooled openhole region. This sequence allows great economy in use of the drill elg and an engoing understanding of the region dilled. In addition, cooling allows use of conventural logging tools and techniques that could not an a in slut temperatures.

As in the JOIDES program, our primary goal is obtaining samples and measurements drilling.

ubidining samples and measurements; drilling methods should be tallored to optimize this goal

Drilling technology should facilitate sample forest collection and borehole geophysical measurements.

2. The hydrothermal system located in volcanic and tedimentary strata should be examined and tested with a horehole terminating in the Precambdan granical angular system. an grante | -3050 m depth).

3. This borchole should be condinuously cored.

This borchole should be condinuously cored. This borchole should be continuously coredite of a recently developed hybrid roller conceptly equalities of a recently developed hybrid roller conceptly of all Evolution of a hybrid roller concePDC core bit.

Trans Gesthermal Res. Council, 4, 1980) is recommended. Use of this method of drilling alloys geo-

such as a grantic pluton overlain by "blanketlng" sedimentary layers.

W. Hinze (Purdue University) elaborated
upon some variations where crustal heat is concentrated by a local good thermal conduc-tor such as a salt dome, by hydrothermal dr-culation, by residual magmatic heat, or by up-

per mantle sources where the thermal effects ive not reciliffused to the apper crust. Hinze cited thermal anomalies within the Mississippi Embayment as a possible example of "channeling" by a good thermal conductor. K. German (University of Nebraska at Lincoln) attributed high temperatures in western Nebraska to the hydrothermal circulation

mechanism, as did D. Hodge (SUNY, Bulla-

in basement rock near Auburn, New York.

lot, to explain high horrow hole temperatures

eter core is cut by a roller cone bit that has a smaller Hence, from the sampoint of livar flow methods HDR exploration in older "stable" continental crust involves three criteria: the ti. Further examination of methods for reducing locating regions of relatively high heat thrw, maximum temperature seen by the drilling bitt, the drilling string, and the measuring equipment is de-)2) identifying regions of low thermal conductivity, and (3) determining radiogenic tirable. Due possible method is use of an insulated beat production in basement rock.

> Because of a far greater density of thermal anomalies, tectonic zones such as the western United States have enjoyed a much higher level of geothermal exploration, and many geothermal areas have been identified. Thus an obvious HDR exploration terlmique cited by D. Blackwell (Southern Methodist University) and M. Smith (Los Alamos National Lab oratory) is to obtain heat flow rlata in the conductive haloes" surrounding known bydrothermal sites. Indeed, these areas often hace sullaient numbers of "dry holes" to make them more interesting as HDR sites. than as conventional sites. Steep gembernal gradients are, of course, direct indicators of ligh temperatures at accessible depths, but Blackwell indicated the need for a more reliable and easily interpreted way of using hear flow to project thermal effects to great depth. Groundwater and Indicathermal water vicus lation orbit buther complications, imbuding extremely high apparent surface heat flow, but there is a growing body of experience in modeling three situations.

### Further Work in Heat Flow Methods

The outlines for adequate heat flow criteria in HDR exploration are given above. However, the panel unted that these criteria could be improved and systematized by some additional elloris.

1. A higher density of hear flow determinations would be extremely useful; it is naturalarly important to extend measurements beroud the immediate area of a wer greathernia or HDR site in order to reduce ambiguity in interpretation of hear three data and to morte convective hear transfer better.

2. Better communication between the arademic community and the geothermal indus-try would be beneficial in obtaining basement inperatures and cores for measurement of ement temperature, thermal conductivity, and heat generation.

3. The Decade of Nurth American Geology DNAG series of maps could serve as the onlet for four additional maps: (1) temperature at 100 of basement, 121 basement heat production, (3) hear flow at basement surface. and (4) surface hear flow.

### Seismic Criteria

If one were to look only at the relatively small effects, due purely to temperature, on seismic velocitics, then only subtle variations in seismological observations would be observed. The utility of seismic methods is in determining crossal structure and thermally associated but often indirect phenomena such as the presence of fluids.

Many of the seismic methods are so well e tablished that they are almost taken for granted. W. Laughlin |Los Alamos National Laboratory) described reflection surceys that were used to characterize depth to basement at the first HDR site at Fenton Hill, New Mexico. Magma bodies are potential HDR thermal sources, and S. Kaufman (Cornell University) showed how reflection profiles helped define a magina layer intruded be-neath the vicinity of Sococro, New Mexico. I Braile (Purdue University) mentioned the strong structural controls provided by selsmic refraction in the Yellowstone-Snake River Plant region; these included substantial velo ity decreases, as much as \$11%, nuributed to fluids. Although the fluids would not themselves be the object of IIDR exploration, they could contribute to heating nearby rack in

Seismic methods are particularly well suited

drilling. Contrary to the case for conventional

reservoirs, seismicity is a negative indicator

Crustal heat flux caries between regions of relative geological stability such as castern or midwestern North America and the more acthe "conductive halo." tive regions like western North America where crustal temperatures are usually hotto locating disturbed zones that have been For stable regions J. Costain (Virginia Polytechnic Institute and State University) cited

increases as the scale

heated hydrothernully or by magnin, K. Aki (Massachusetts Institute of Technology) museveral geological settings that seemed prom-ising for HDR. These take advantage of the fact that heat flow is the product of thermal ed that almost nil the hot zones currently ex-Lablished as geothermal sites are characterized by deep crustal inw-velocity cores. These comprise not only glant systems such as Yellowstone, but also the Jeniez Caldera Jalgradient and thermal conductivity; therefore, regions of low thermal conductivity can have though velocity surveys inside and outside the rather high thermal gradients and hence high caldeta dial not play a role in originally temperatures at moderate depths, even choosing this HDR geothermal site). Three-dimensional telescismic P wave delay studies ough heat flow is only average. Heat flow is further enimoced if local crustal heat generahave strikingly oudined several low-velocity tion is high. Hence, two litteresting HDR poscores that represent hot rock that provides sibilities would be regions of normal gradient heat both to the local hydrothermal systems but deep, relatively insulating sedimentary cock and regions of high heat generation. and to the halo of hot but dry rock. Seismic ity serves to delineate possible HDR reservoirs in a number of ways: It can locate possible intrusions such as the Socorro magma layer; on the local scale it can provide information on stress directions as a guide to

for magnitude systems because of the danger of induced earthquakes and of water bass rlineargh active landts.

### Further Work in Seismic Methods

Future work in seismic HDR exploration should take advantage of those properties that are most sensitive to crack structure and pure thirds as ways to define the general form of geotlærmal str**ac**maes: t| i teleseismic S wave structure to define three-dimensional (3-D) structure as degre for P waves, (2) determination of S velocities, Poisson's rations, and Q-1 in retraction surveys, (3) controlled surface wave studies to improve resolution of V, and Q, 1, 14) detailed similes of known conventional hydrothermal and HDR areas to gain experience in seismically delining these

### Magnetotelluric Criteria

Electromagnetic methods, magnetotellurics (MT) in particular, are extremely useful in gentlernal exploration because of the sensitivity of rock combicustry or water content and to elevated temperatures. MT can target HDR resources in two important ways. As a regional exploration method, MT can be used to map the crustal deep electrical conductor, M. Amler Hos Alamos National Labpraparyl showed like long two-dimensional modely developed from approximately 200 M.F. soundings in Arizona and New Mexico. These madels indicate strong evidence for a correlation between the depth to deep electrical conductor and surface fiest flow as well as with regional tectonics.

One of these models, from Selignan to Vinna, Arizona, was used in a presentation by E. Aiken (University of Texas) and M. R. Hong (Polyersity of Texas) to indicate a correlation between the depth or the deep crossal conductor and the denth-to Unrie point. M. Ander and T. Shankland (Los Alamos Notional Laboratory) showed results of a correlation study of worldwide MT field data and crustal temperature obtained from surface hear flow. A pronounced result of their storts was that even the most resistive crostal regious have combactivities several orders of magnitude better than laboratory samples and that this is easily explained by the presence of volanles, water in particular. Most turportantly, the data could be well represented by a smalight line fit on a log versus 1/T plot indicating an excellent correlation between crustal electrical combictivity and crustal remperature, G. R. Jirarek (San Diego State University) suggested that the deep crustal elecmical conductive horizon may occur where an impermeable, due the cap traps pure thirds beneath. Distrile flow mechanisms are there mally anivated processes that involve charge defects, lattice dislocations, or aromic diffusion, all of which enhance solid state electrical conduction. If active maxima injection rlestroved the integrity of the ductile cap, trapped fluids would escape, resulting in an overall decrease in combactivity. The final electrical signature would depend on thermal gradient, relative impermeability of the cap. extent of the pure thirds beneath, and amount of magina intrusion. Because tenperature would likely be the major variable in a given geologic province, Jiracek also felt that the depth of a conductive layer, even if caused by a ductile layer, would provide a measure of the thermal gradient. Therefure. it is likely that estimates of constal temperature and regional heat flow can be obtained from estimates of the depth to correlal electri-

والمجانب والم

As a local exploration method, MT can be used to nunp the structure of resistivity changes at a potential HDR site. This requires high quality ATT data and a tight MT station spacing. For both the regional and the site specific exploration, problems exist in modeling and in interpreting the field results. A. Orange (Emerald Exploration, Inc.), S. Park (MIT), and D. Chambers [Woodward-Clyde Consultants, Inc.) discussed the name of some of the pitfalls of AIT interpretation in both two und three dimensions. MT interpretation is a complex art, even in many cases where the data appear straightforward; recognition of this complexity is a major step toward the realization of the method's full capabilities, Intense study ul a wide variety of two- and three- dimensional models will proelde the interpreter with valuable, critical insight. MT surveys should be planned by using this insight.

### Further Work in Electromagnetic Surveys

The electromagnetics working group had several specific recommendations for further.

I. In the past decade, well uver 5000 MTsoundings have been completed in the United States. These represent on extraordinorily. valuable data bose for determining the deutli to the deep electrical conductor. It was suggested that these data be compiled in a single data base and analyzed. An international prolect to do this has been endorsed already by the National Academy of Sciences. This would be of value in further confirming the correlations between electrical conductivity. heat flow, depth-jo-Curie point, and regional

THE RESERVE OF THE PERSON OF THE PARKET

2. A continuous exploration program, us-ing electrical mediads, should be directed towird locating conductivity amonalies in the United States. These could be either hydrothermal or HDR systems. The distribution of heat flow and electrical properties may well be useful in differentiating the two types of

3. A major uncertainty exists in knowing how to interpret enhanced electrical conductivities in the crust. Possible mechanisms are mimerony. Although we have some measure of understanding of these effects, there is insufficient information to judge how these effects persist over time. For instance, can pute fluids persist in enhancing confluctivity over geologic time at temperatures of several hun-dred degrees or do they form hydrated minerals and hence change ruck conductivity? In addition, larg-term measurements of electrical conductivities in rocks need to be undertaken at geologic temperatures and pressures to understand changes with time.

### Gravity end Magnetic Criterie

There are many ways in which gravity and ninguetic methods can be applied to exideration for 11DB resources. Gravity analysis is well suited for mapping depth to rocks with low permeability. Magnetic methods are not osually as well suited for this because magnetic "ha sement" seldom coincides with geologic "basement." Gravity can be used to some mimic extent in studying the nature of the sedi-mentary blanket. Buth gravity and magnetic surveys are important methods for delineating both regional and local structure in the Phanerozok and the basement. They are particularly good for locating faults, suture ziones, and old rift structures. Magnetic surveys may be used to determine depths to the Curie (sotherm: A shallowing in the depth to the Carrie isolierur may suggest a thermal upwelling and therefore a possible HDR tar-

J. Costain, L. Ghiver (Virginia Tech), D. Hodge, and K. Fromm (SUNV, Huffalo) described the use of gravity data in targeting HDR sites in the eastern United States, while W. Hinze, L. Braile, R. von Frese (Purdue thiversity), G. R. Keller, R. Roy (University of Texas at El Paso), and P. Morgan (Lamar) and Planetary Institute) described gravity applications in the midcontinent United States. In these studies, gravity and magnetic data covering broad regions have been observed, compiled, and in some cases liketed to en-hance particular attributes of the anomaly field. These maps are proving useful reconnaissame prob in mapping recronic/hibologic regimes that serve as guides to localize more

detailed geophysical and geologic studies. In particular, gravity and magnetic surveys have helped in investigations of silicic and al-

# 30th Pacific Northwest Regional Meeting

September 30– October 1, 1983

Western Washington University Bellingham, Washington

Convenors: Myrl E. Beck, Jr. and David C. Engebretson

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Special symposia will be held on Evolution of a ceanic plates in the eastern Pacific: volcanism and seismotectonics of the Cascade Range; evolution and character of the crystalline North Cascade Range of Washington and British Columbia; Terliary lectonics of the western Washington and Oregon Coast Range province, with special allention io the origin of sedimentary basins.

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kalic intrusive budies, which are potential radiogenic heat sources. Silicic intrusives are community characterized by gravity minima of the order of a few tens of milligals and negative magnetic anomalies. Phovever, some plu tons studied in the midcontinent are associated with relatively high magnetite contents re-

sulting in strong localized magnetic anomalies. The gravity signature of these high-magnetite plutons is alisent or slightly positive. By contrast, alkalic intrusives are generally marked by both intense positive gravity and magnetic anomalies.

In two separate papers, I. Won (North Carulina State Universityt, C. Aiken, and B. Hong discussed the inversion of magnetic data to determine the depth to Cutie point isotherm. Aiken and Hong described how depth to Cittle point estimates they made along a prolife from Yuma to Seligman, Arizona, rourelated with estimates of alepth to ileep crusial electrical conductor made along the same profile by M. Ander using MT data.

### Further Work on Gravity and Magnetic Methods

The gravity and magnetic working group identified several areas for further work in plying gravity and magnetic methods to

 More case studies are needed. 2. Petrophysical studies are needed to ohtain precise measurements of density and magnetization of rocks of interest. Studies addressing the magnetization of rocks as a function of temperature for extended times are considered especially important.

3. Gridded liltered data sets must be gener 4. Although naignetic maps are widely available, digital magnetic data are not. It

would be useful to make such data available 5. It would be prolitable to further study the correlation between the depth-to-Curie isotherm estimates and surface heat flow and the depth to the deep crustal electrical con-

### Ceologic Methods

Leologists attending the workshop all em-phasized a multidisciplinary approach to HDR exploration. Their role is to provide the geological framework for geophysical data in regional HDR sorveys and to characterize the genesis and thermal history of heat sources within geothermal areas associated with recent redemism or other silicic platons. The geologist's role has changed little since the Hot Dry Rock Resource Evaluation Panel (HDRAP) of the Energy Research and Development Administration defined the variety of logical sorveys needed for HDR explorainn and development.

Within igneous systems, which make up nost of the known geothermal resource areas IKGRA's) of the United States, the geologist's role in delining the HDB resource is substantial. To understand the extent and magnitude ol hydrothermal and HDR components of an igneous system requires detailed information on the structural setting, ages, distribution, volume, and composition of volcanic onits, the hydrologic setting, and chemistry of rock-water interactions within the system. The rate of fraettire formation and fracture healing within these systems must be determined. All this resource definition requires drilling and careful analysis of cores, cuttings, and geophysical well logs.

Some of the most useful data sets for the geologist are those from the many wells drilled for hydrothermal development that have high temperatures but no production of fluids. By keeping records of "hot but dry" wells within KGRA's, the high-grade HDB resource may be best evaluated.

Examination of regional thermal anomalies is mostly in the realm of geophysical surveys. However, the characterization of HDB reservoir rocks depends upon good physical and petrologie studies.

E. Padovani (National Science Foundation) discussed the utility of petrology of xenoliths from young vidcanie rocks as a toul for geo-thermal evaluation. It is possible to use mineralogic geoharometers and geothermometers to calculate thermal gradients; these serve well as supplements to measured heat flow.

A major problem in HDR resource evalua-A major problem in Fibra resource evalua-tion is determination of changes in the stress regime and perineability with depth in a vari-ety of geologic settings. These data are need-ed for klendlication of rock units to serve us HDR reservoir racks.

Compllation and evaluation of existing geo-logical and geophysical data would be ensied if there were a clearinghouse for published and proprietary information. Also needed are better curatorial facilities for the preservation of drill cures and cottings; perhaps such facilities could be established through a continental scientifie drilling program.

### Cose Studies

W. Laughlin and M. Smith described the process of selecting the first hot dry rock geothermal site in the Jemez Mountains, New Mexico. Of primary importance to site selec-tion was the published data available on the extent, age, and nature of the Valles Caldera. Heat flow measurements along the western edge of the caldera, arructural mapping, and a slim exploratory drill hole to the Precaubit

n mang in



# 1983 AGU Fellows



Peter L. Bender-Far his innovative work in the development and exploitation id new aidvanced systems for generation of precise data for a variety of geophysical applications; vari-ations in the earth's rotational rate; lunar orbit and lonar mass distributions; technic plate motion; crustal movements in seismic zones; global gravity field; and precise genmetric positioning.



Marx Brook-Fig extensive and original contributions to physics that have resulted in ncreased understanding of electrification and severe storm dynamics and their effect in the atmospheric processes.



Harmon Craig—Fin sustained and diverse contributions of the most fundamental nature to the field of geochemistry.

Herbert S. Bridge For continued contributions of the highest scientific quality to time understanding of the solar wind and its inter-action with the planets of the solar system.

Frank M. Richter-For providing a hetter understanding of convective processes in the

and Jointing within the phitonic-metamor

reservoir rocks was not possible and could be

determined only by drilling. Drilling slim ex-

vides many of the answers and appears to be

ploratory holes, with nomerous cores, prit-

tninly was at the New Mexico site.

of the degree of faulting

an "basement" were key factors in site selecof deep aquifers from the Denver Jucket basin. High heat flow within nor Nebraska is more difficult to explain: be related to water flow along fractures the Dakota group or to buried grank per tons. More drilling into Precambran bee ment rocks is needed to evaluate the geothermal resource of Nebrasia, but a f

Andrew P. Ingersoll-For his control

to the understanding of planetary atoms pheres through the interpretation of spare

Lynn W. Gelhar-For his contr

the science of groundwater hydrology

particularly for his application of socks methods to that field.

G. V. Gibbs-For greatly expanding of

knowledge of crystal structures and cryst

themit al chia acteristics of many and the

Dennis E. Hayes-For constanting of

lattians in marine geophysics—explorate

concents, and syntheses.

groups of minerals.

the best local site evaluation technique; it cer-Geothermal exploration strategies and the Rhine Graben by the European Committees were presented by B. Hoffer Committees were presented by B. Hoffer Committees was National Laboratory and General Walters. Those include (1) work an include (1) work and in Hodge and Fromm osed heat flow, temperature gradients, and gravity surveys to search for hidden the mal anomalies in the northern Appalachian basin. Initial results indicate that variations in temperature gradi-Walterl. These include (1) work on the ents are due to heat generation in granitic Walter]. These include (1) work of the greissex and schists of Hercynian agreissex and schists of Hercynian agreisses and Paleotte ites of Carboniferous age, and Paleotte include the gravity anomalies; and (4) terionic analysis gravity anomalies; and (4) terionic analysis Diaptric rise of mantle uniter the kinds of the paleotte ites and higher tomperature gradient including the control of the paleotte ites of an addition it those guivest described above, refractions phitons in the basement (sintlar to the anomalies described by J. Costain in the Atlantic coastal plain). Recent drilling in western New York state has indicated that not all thermal anomalies are related to buried granitic pltttons; some appear to be the result of hydro-thermal circulation along faults and fractures those surveys described above, refraction reflection seismic profiles. Mr surveys magnetic profiles. Heat flow measurements, bottom-hole tem-peratures in oil and gas wells, and residual

Bouguer gravity maps were the basis of a geothermal resource assessment of Nebraska by Gostfold and German (University of Ne-This whening report was contributed by G. Helken, M. E. Ander, and T. J. Shankland, Las. Almus National Laboratory, Las Aleast, 12 braskal. Two areas within the state have high Helken, M. heal flow. Within the panhandle of Nebraska Las Almuos the anomalies appear to be due to updin flow 37545.

magnetic surveys, and electrical surveys,



Hugh H. Kieffer-For his contributions to the investigation of planets through infrared



Incob Rubin-for his potstanding career in science during which he has made significant contributions in soil science and in the theory of solute transport by groundwater.



Edward C. Stone-For the continued excellence of his research in cosmic ray physics and for his extraordinary efforts on behalf of his Jelhoc scientists as Voyager Project Scien-



Michael W. McElhinny-For mustanding

contributions in paleomagnetism and plate

John G. Ramsay-For cevitalizing structural Realogy by careful quantitative studies of Remingly nonor features, showing how much



Janes R. Wnflis-For research and leadership in the application of statistics and stachastic processes in hydrology.

# Chapman Conference on Collisionless Shock Waves in the Heliosphere

February 20-24, 1984 Silverado Country Club and Resort Napa Valley, California

Convenor: R. G. Stone

Abstract Deadline: November 1, 1983

Invited reviews and contributed papers in the following general areas: Overview of the collision and contributed papers in the following general areas: of the collisionless shock, macroscopic aspects of shocks, microscopic aspects o shocks and particle acceleration. Typical subjects to be covered include:

- Why and where shocks form in the heliosphere?
- Shock dynamics and evolution: Shocks associated with solar activity, plenetary bow shocks, corolation shocks, and shockshock interactions.
- · Subcritical, supercritical, quasiparallel, and quasi-perpendicular shocks.
- Diselpation mechanisms. · The foreshock.
- · Perticle acceleration mechanisms.

Conlact: AGU Meetings, 2000 Florida Avenue, N.W., Washington, DC 20009 D.C. eree 462-6903 Ioll free: (800) 424-2488

Call for pepers published in EOS, May 31, 1983

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Applications for membership have been re-ceived from the following individuals. The leuer after the name denotes the proposed primary section affiliation; the letter A denotes the Atmospheric Sciences section, which was formerly the Meteorology section.

### Regular Member

Kathleen W. Baird (V), Vira Chankong (H), Claire B. Davidson (Ht, Peter M. De-micco (H), Stephen J. Derksen (T), David A. Gell (SA), John D. Horel (A), Gary R. Huher (T), Jess B. Kozman (T), Eve Kuniansky (H). Russell W. Laforce (H), H. Richard Nashurd V), James K. Nicholls (O), Michael Rowen (Vt. Steven D. Scott (Vt. Ping Sheng (S), Joseph W. Troester (H), Roger A. Wait (S), James E. Wolfe (St.

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Nominations for Fellowehlp in the Union are being sought by the Fellowa Committee and the Section Selection Committees. Nominees for Feltowship should be scientists who have attelned acknowledged eminance in a brench of geophysica. The total number of Fellows elected each year cannot exceed 0.1% of the lotal memborship. To be considered by the Committee, nominations for Fellowship in AGU must be made

on the form below. If more apace is needed, attach a saparate sheet.

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Business Address (Including Position held)	
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Education (degrees, institutions, major lield	1
Protessional Record Lincluding special hon	ors)
Membership in other Sciantific Organization	s
which have not yet been accepted for public	ona (noi abstracts, book reviewa ot papers (callon).
nature of your acquaintance with the nomin	st include: (1) An indicellon of the length and nee; (2) the Nominee's contributions to the inee's scientific ebility; (4) a one-lina citation,
"Fox", summarizing why lie no	mines ehould be elected a fallow.
	ominee ehould be elected e fellow.
Signed	ominee ehould be elected e fellow.
Signed	Dele
SignedSponsor'a Title and Affiliation  For a liel of current Fellowa, call or write	Dele
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American Geophysical Union 2000 Florida Avenue, N.W. Washington, D.C. 20009

### Electromagnetics

8701 Ansonman (Roiss measurements is planess)
QUASI-THERMAL SOIRE CORRECTIONS DUE TO PARTICLE IMPACES
OR EMISSION

8. KETES-VERNET (CSES LA 164, Department Rechatches Spatistes, Observatoirs de Paris-Haudon PSIIS Mendon Principal Codox)

Rerent measurements at the "quesi-thermai" noise is a sisbie planes have eshabised an additionnal local and hiffuse nofae below the elected planes fraquency; this has been suggested to be due to Empatte or sminslos of charged particles on the antenns surface. To investigate this problem beyond the previous smi-heuristic evaluations, we satend the quasi-theren noise taliculations, we satend the quasi-theren noise calculations, we satend the quasi-theren noise calculations, to satennas which are ear fransparent to particles. Me apply the resules for easil redius apherical and cylindrical satennas in so isotropic equitiorium pisses, at fraquenties at the according equitiorium pisses, at fraquenties at the according to the pisses of the avent than holes pisms component which has the failowing praparties : 1) for email double-spheres actumes, it has as f-2 spectrum second the pisses actumes, it has the assess according praparties : 1) for email double-spheres actumes, it has as f-2 spectrum second the pisses irequency; 1 just below, it is of the sees according to the bear of the sees according to the component of the thermai noise lithe antenna langth is larger, is for fine cylindrical extension, is is only broadly f-2 bason the pisses frequency; 1 just below, it is governed to the solar wind and terresettial especial phare (Antennas, the rase looke, plasmas).

J. Gouphys, Res., Sius, Papor JA1011

### Exploration Geophysics

OSIO COMPUTER SPRICATIONS

SUTTREVOIR DIP CILITIE

ESO OSIO Esciante methods
O ava Hafe I Department of Gauphysics, Etanlord
Oniversity, Stanford, CA 963011 Jos Y. Glasshout
Oip filters anable a geophysicist to Olacriminate
betreen various salamic erents on the basis of apparent
dfp. The frequency-wavenumber 10,2% domain seems an
attractive domain to perform dip filtering because ir
peraits the application of so arbitrary transfer
function of dfp. Selenic applications of dip lifering,
however, saldow require the flexibility offered by the
lu, ki domaint one may siss he withing to sacrifies
this itensibility to obtain features not possible with
(U, ki domaint one may oisen he withing to sacrifies
this itensibility to obtain filters. Exreples are lift rise
and sease vertability, 121 Birtble ereatment of
computational grid houndaries, and if an efficient,
returative implementation. We describe a (e, xi domain
dip filtering method with those features.

In the derivation of a If, xi domain filter, wa first
discuss fe, xt and (U, xi domain filter), while not
fully possessing the advantages of a (t, el domain
filter, these Bilears are no attractive combination of
two very efficient and commonly available processes:
(11 one-dimmafone) Sutterwarth filtering and (21
one-diamasionat Pourles transforms. We then derive
the features moteh shows.

GEOFMYSICS, VOL. 88, NO. 8

OS20 Setwic mechods COMEMENT BOSS IR MASITE ESISMIC DATA Seen Larour I Vastarn Ceophysical Coopany, P.O. Sox 2489, Bouston, Tt 172521 Son Casmbers, Esi Yang, Wait Lyon, and Willon Val

Bouston, Tt 172521 Son Cambers, Sai Vang, Walt tynn, and Willow Val.

Osspite algorificant edvances in marine strasser design, selemic date are often plagued by coherant noise baying approximately if mare movement across stached sections. Sith an understanding of the tharacteristics that distinguish such noise brom signat, we can decide which noise-suppression tachniques to use and at what stages to apply them in acquisition and processing.

Three general mached sections are examined; direct and trapead waves that propagate octward from the material source, cable source for classed by the rugging action of the boat and tail budy, and seattered energy from irregularities in the water bottom and seattered energy from irregularities in the water bottom and sub-bottom. Opending upon the machesian, contray different coise patterns can be observed on about profiles and common-adaplat icase gathers; these patterns can be diagnostic of the dominant behands in a given set of data. Yield data from Causde and himsts auggest that the dominant moise is from each a caterial within the shallow sub-buttom. Inline type of some, while not obvious on the shall records, is actually advanced by CMF stacking. Moreover, this noise is confined to marine data into scaled data as vall.

Of the many processing tools available, woveout efficaring is best for suppressing the moise while processing algorit. Since the acceptand ones and a data is a far suppressing the moise while processing algorit. Since the acceptand ones and a sale and each interest ones.

exhibit a linear woveset pattern on CPP-sorted gathers, noweout fittering must be applied either to traces within shot records and tommon-reteiver gathers or to stacked traces. Our dath example demonstrates that eithough it is more cosfly, moveout Filtering of the unstacked data is particularly affective because it conditions than data for the critical data-dependant processing steps of predictive deconvolution and velocity onetysis.

Payetcs, VOL. 46, 80, 1

OPIC Seisule mathods
STRUCTURAL INVESTIGE OF MAIT DOME FLANCE
S.T. May (Compuse Empioration, Car., 1618 Coie Elvá.,
Sta. 110, Solden, CO 804011 J.D. Cosy
Accupate location of the acit-sediment loturface is
one of the fleat problems to be solved during
amplocation around sait domes. Revewer, determination
of each boundering from actuallo date has been
autoriously miseful asso though forward modeling has as provested acquired and downs. However, determination of Sain houndaring the from a siamic data has been mutaridusly miseful sain though forward modeling has shown that the sait flank reflection can be one of the highest suplitudes so a saismic resort. The mourtes of difficulty are last conventional data sequiations and produced are last conventional data sequiations and produced are last that the vertical are last the said flanks. For manaple, it implements are the said limits. For manaple, it implements are deading velocities are used during, probleming, the said flank certicals can be an attremuted as to be mochastrophic. Invasion modeling by tay methods is house to 0s as altable trainings for resonance this reflection are identified. Sait flank rither than the modeling a through applications are identified. Sait flank rither too have been resonversh in 200 flaid-rizorded examples, through application of modeling the said application of the said areas shed areas ather raying one seampts problems. The inverse heads competed to one seampts problems. The inverse elike the rates up to 70 depends ath in accase to seathful paragraph are acquired to competed to her lifting dath, in accase to elike the season demanth are although managed as the raying the seath from the season demanth are although managed as a case of a significant competed to her lifting dath, in accase to elikely there are the season demanth are although the problem of the season demanth are although the problem of the season demanth are although the problem of the problem o

striting: dip rates of 90 Orgrees are achieved and the model shows a slight overhang of seit. These results show there is nothing in principle to prevent inversion of steeply dipping attructures from surface-recorded seissic date, including such settrome creeks as overhanging sait does.

GEOPHYSICS, 90L. 45, NO. 8

overhamping said doese.
GEOPHISICS, 90L. 45, NO. 8

0910 Esismic methods
COMPESSATION OF MANIEZ SHIMIC DATA YOR THE EFFECTS OF
HIGHIT VARIABRE WATES DEFIN USING RAT-TRACK MODELING.—A
CASK RISTORY
ALLA Deat (Cirism Service Company, thorny Essources
Group, Tech. Center Soom 9175, Sox 3008, Tules, OR
14071
Variable water depth can cause severe degradation of
usrine salanic data. This paper presents a tachnique
for correcting the affects of water depth variation and
is a case history of applying the technique to a line
of data from the Philippines offshore. The line crosses
a deep subseries valley, it will be shore that when the
water depth changes rapidly relative to the cash
length, the timing variations introduced will not be
static. They are dynamic, not static, because they
differ for different event thems of a single trace. To
compassate far Class dynamic their watering variations, a
two-stage technique was used. A ray-risca modeling
program teleculated the traveltimes to soveral depths,
both for where the valley is present and where it is
abusent. A second program used the model results to
shift the seaples on all selent traces to the time
they would have if the valley were not present.

The most difficult part of this project was finding a
good model. The model is composed of two parts: the
dapth of the sea floor anh lide velocity-depth
relationships halos the sea floor. The depth of the sea
floor was sucleated from the first errivals on the
near-offset traces of the seismic data. This was
difficult Socause of the shellowess of the normal sea
floor shows 80 at anot the large offset hatween the
shot and the first group (211 ml. The first srrivals
was beed waves, not reflections, off the sea floor.
The reflections from the valley had to be aligned to
obtain accurate dapths. The subsay alocity-depth
relations also had to be assisted at no the assessing
date. However, the results of applying parely
state. Thus, the data were further processed to produce
an optimal processing to produce a much better floor
data.

CEOFEVSICS, VOL. 48, NO. 7

O990 Instruments
THE RESONANT HOUSTIC SOLSSS--h COSTINUOUS-FREQUENCY
MARINE SETSELC SOURCE

a.G. Burdes (Saddia Pational Laboratories, Cauphysits
sivision-1541, Albaquarque, NM 87161) S.O. Hills
h marine satemic source is described which produces a
continuous jou-fraquency [10-700 Sel barmonic signal.
High scountic power levels (AGOW) are reached by using
a resonant system. The saisult source has been
successfully tested in labe and ocean environmence.
Osophysical applications era discussed and
modifications are described which would a.'ow the
saurce to be operated in a sweat-frequency mode.
GEOPHTSICS, VOL. 68, NO. 8

OPPS General or miscellangums
AM OPPSATES SOUGUES ABSHALT MAP OF SOOTS-CSVTShL WEST

APRICA
APRICA
Ovoid A. Eastings (Tasknico for Government Services,
tnc., ENG Data Gusser, Eloes Yells, SO 57198)
h new Eougner gravity anously map compiled for
western Africa adds data for Ohans, Guinea, and
Liberia.
The new data add detail to a hey patt of the Eburnesa
shield and assist in the development of a model of
rifting at the time of the Eburnesa orogeny, 2000
militan years ago. This model lacindes a Yraesvart Yor
the deposition of the region's mineral deposits. The
model sed satising field data can be used to guide
foture adsarals explanation in the region.
GEOPHYSECS, Vol. 48, MO. 8

SOPP General or miscellengous
RECERT DEVELOPMENTS IN YES ONE OP SORFACO ELECYSICAL
METHODS FOR OLL AND CAS REPLONATION IN THE BOUIST UNION
Orism E. Splas (Formarly SCOED, Ganzer, and Eureen of
Minaral Sensurcus, Canharra, Australia; presently
Siestromagnatic Survays, inc., 2161 Shattuck Avanua,
Ble. 303, Serhalmy, CA 941041
A great deal of interest has been expressed in
Sasters countries during recent years on goasible
applications of surface electrical methods to oil and
gas exploration. It has been reported that these
methods are widely used in the Soviet Onion, but to
date for exactorial datalis have been systematic. In lare
1879, the author visited the Soviet Smice ander the
auspices of the Australi-1952 Agreement on Scientific
Gooperntion, with the purpose of studying retent
developments in electrical and electromagnatic [EM)
methods. This paper presents a sametry of the use and
applications of those wathods to ofi and
applications of those wathods to ofi and
applications of those wathods to ofi and gas
emploration, and includes a number of case histories.

The methods can be broadly classified as follower
southing for structural mapplog, aconding to messors
the geomiectric properties of the oli-basriog hurison,
and indiract eathods which datest the presence of a
mengoeiotalluric iNTI melhod nad trenslant sausding in
the sear some (2582) are videly used for deep seacoding,
aspecially in arreas where a sismic eathods are
ineffective. Rodern 2582 equipment can measure over
3 1/2 decades of time, from 0.1 mess to 4A.8 sec. The
transatter constate of a large (1000 ml aquare loop
carrying t AO A reatengeier waveform, and the receiver
is a melituum noil incated at the senter. heptibe of
aupioration depend upon geologic techniciens, but they
are typically of the order of 3 to 4 he.
Statatical data, based on logstag, of the
generalist of the sorder of 3 to 4 he sectiver
is a melituum onli incated at the senter heptibe of
aupioration depend upon geologic techniciens, but they
are typically of the order of 3 to 4 he

### Geochemistry

1410 Cheetstry of the etmosphere
VAROR PHASE AND PARTICULATE SCIENIUM IN THE MARINE
ATMOSPHERE
Byard M. Mosher (Center (or Atmospheric Inemistry
Studies, Gradeate School of Osenangaphy, University of
Rhade island, Ozabl), Robert A. Duce
Particulate and vapor phase sampling has been
conducted at six larations ranging from a New England
urbus location to northern and southern hemisphere
renote island sites. Perticulate algorium
concocirations range from 0.3-1 ng/m³ is urban
locations to 0.06 ng/m³ in remole southern hemisphere
areat. At many diverse locations such as Spitsbergen,
Bermude, and Meyati, perticulate Sa concentrations of
0.4 to 0.3 ng/m³ ere typical. This may represent a
northern hemisphere marine background level but more
extensive southern hemisphere sampling is necessory in
order to document ony interhemisphere differences that
may exist. Vapor phase selenium typically constitutes
roughly 30 percent of the total (range 65-16 percent) st
most locations except the Paru sousial region where
copper swelter particulates influenced the
particlis/vapor pertitioning and above the merine
boundary layer in Heasti where roughly 45 percent of the
satenium is vapor phese. Vapor concentrations renge
from 0.6 ng/m³ in urban areas to 0.02 ng/m³ at tho
southers hemisphere islaed of Sanoa. Particulate and
vapor phese selenium appear to be produced balh
anthroposenically and naturelly sed the oseen appears to
be an importent source tor vapor phose selenium, his
oceanic vapor phase may be en important fector in
maistaining the emonalous smrichash to (perticulate
selsaiue in remote regions. (selenium, vapor phase)
J. Goopiya. Rea., Orean, Paper 100856

### J. Geophys. Res., Orean, Paper 100856 Geodesy and Gravity

igfs noistions of gravity observations to Sectonics and Sectarsy
THREE-GIMESECONAL GEOMETRY OF THE GORDA PLATE EINEATH
HOPMETRO CALIFORNIA

B. C. Jachens U.S. Geological Survey, Hanto Park,
California Medaly and A. Griscon
The immediate residual gravity field over northern
california displays a gravity gradient interpreted to
reflect the mouth adge of the Gorda plate where it is
subducted emetured beneath the North American piste.
The locus of points of manisms slope adjines a line
trending S.60° s. from a quantum slope adjines a line
trending S.60° s. from a quantum point where the
bursed piste boundary is inferred Eros magnetic and
asimicity data. Bouthmant trus the quantum persiteis the
strike of the Signon tracture zone and the prosent
direction of resistive motion between the Pactit c and
northern Gorda plates. Calculations from the tore of
the anomaly yield depth satirates that fit an eastmouthous plunge of approximately 9° for the top of
the Gorda mouth edge. The sense of the anomaly
litigher gravity to the gouth supports the hypothesis
that a window developed in the subducted slab east of
the Ban Ambress tault and mouth of the Gorda plate.
South of the Gorda houndary the base of the North
American plate is than in contact with hot material
from the suthenoughers that I maded the window.
Secause the overlying North American plate has been
nowing relatively south across the Corda boundary, the
North American plate tenest to the the Corda boundary, the
Houndary are the rise the North American plate may be
decoupled from the underlying material at a dapth
slightly deeper than the dapth to the top of the
Boundary are the rise the North American plate passed
over it. Corda place, gravity, subductioni.
J. Geophys. Res., Red., Papar 150910 J. Goophys. Res., Rad, Paper 350910

1970 Standards and Absolute Measucements
RESULTS SPOM AN AUGULTE GRAYITY SURVEY IN THE UNITED

RESULTS FROM AN AUSOIUTE GRAVITY SURVEY IN THE UNITEE STATES

8. h. Sumberge. J. E. Falier fjoint Institute for Laboratory Astrophysics, Unitersity of Golorsdo and Mationat Bureau of Standards. Soulder. Colorsdo. 601031 sed J. Guzhaind

Using the recently complated Jila sheduta gravity mater, we made an sheolute gravity survey which cavered twelve sites in the Delied States. Over a period of eight seeks. the instrument was driven a total distance of nently 20,000 ha to sites in California. East Maxico, Golorado, Vyening, Saryiand and Nassachusatts. The time spent in carrying out assourcement at a single location was tynically one day. A measurement scuracy of strough is voliced to the sites. (Absalute gravity, sceniaration of gravity, gravity, nearly survey).

J. Gasphys, Res., Red. Paper 180016

IPTO Etandards and Absolute Measurements
RESULTS FROM AN MESOLUTE ORAVITY SUSVEY IN THE UNITED
STATES

PRABLICIS FROM AN ARSOLUTE ORAVITY SUSVEY IN THE UNITHO STATES.

3. A. Zunbergs, J. E. Faller (Joint Lostitute for Leboratory Astrophysics, University of Colorado and Metianal Dursay of Standards, Bouider, Celorado, 20309) sed J. Cachwind

Using the receolty complated Jila shaoiute gravity metst, we made an absolute gravity surrey which covered twelves in the Melted States. Over a prelod of eight weeks, the instruent was driven a total distance of easily 10,000 he to sites in Califorofs, Nes Mexico, Colorado, Wyomleg, Maryland and Massathusatts. The time spent in terrying out an ansutement at a Single locatice was typically one day. A massurement assurety of sround 1 x 10<sup>-7</sup> m/s<sup>2</sup> (10 µgs) 1 he bilaved to have been obtained at math of the effect. (Absolute gravity, acceleration of gravity, gravity, gravity, arealty, gravity, and pages. 120016.

### Hydrology

COMPUNCTIVE USE OF GROUND WATER AND SUPFACE MATER FOR IRRIGATED AGRICULTURE: RISK AVERSION John P. Bredshowf: U.S. Geological Survey, 145 Biddleffeld Road, Healo Park, California, 940251 and becomes conn r. Predehoeft U.S. Geological Survey, 145
Siddisfield Road, Mealo Part, California, 340231 and
hobert h. Young (Department of Foorcatca, Colorado
Scate University, For Colline, Colorado, 80231
In earmining the South Platte system in Colorado
where survana water and ground water are used conjunctively for irrigation, we fied the actual istailed
well capacity is epproximately sufficient to irrigate
the surfara water and ground water are used conjunctively for irrigation, we first the actual istailed
well capacity is epproximately sufficient to irrigate
the surfara area. This would appear to be an over
investment in vell capacity. In this paper we examine
to what extent ground water fo being developed as
theuristic against pariods of for attending the hydrology
of a conjunctive actrees aguifar ayalem to a behavioralaccountry model which incorporates farmer behavior to
such a system, we have investigated the accounts of an
area patterned after a reach of the South Platte Valley
in Colorado. The results suggest that under current
accountry conditions the some reasonable ground-waterpumping capacity is a total capacity capable of
irrigating sufficient cell capacity to tribate all
available acreage has two becefits: (1) this capacity
maximises the supred nat hemefits; and (2) this
capacity aiso alminises the variance to semme laily sero.

As pumping capacity is increased is diminished. Poor
formorate are obspensed for by pumping ground ceter.

Mater Resour. Refs., Paper Mu851

1110 droundwaCer
TRANSPORT OF REACTING SCALITES IN POSSIBLE WEDLA: RELATION
SENTED HAMMERATICAL NATURE OF PROBLEM FORWLATTON AND
CREMICAL NATURE OF PROTICES
Jacob Sides (to a. Geological Survey, Meels Park,
California, 940/5)
Examples involving all broad reaction nicessal show
that the mature of transport-affecting chemistry may
have a profound "Fract on the mathematical character."
of sofuta-transport problem forwing the Substractive
mathematical discretive among such forwalficacing is
throught about principally by reaction proprieties
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3160 Runoff and Streamflo

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(CONGNIC EVALUATION OF WATER HARVESTIMS IN MICECAICURENTS
G. Oron (Bon-Gurion Deiversity of the Heger, dece
Bleustein institute for Baseri Research, Kiryal SaOoker 04900, Israel), J. Don-Ather, A. Isra and
lh.H. Ooars
A cost-benolit ensitys of the micro-catchrantwater-herveating (MCMM) technique has shown that is
highly dry zone (I.e. annual precipitation of less
than 150 mm) the predicted income is negative, he
introduction of modified technology improve water
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has modifications are associated with additional
expenses leaving the additional benefit questionally.
A sost-benefit enalysis of HCMM without instit. Known,
in e highly dry zone the cet income is still regitle
(elihough only slightly) while in dry zone (I.e.
ennual precipitation of ZSD mm) it becomes positie.
(Cost-benefit, micro-celchoent, inseris, runoff
afficiency).

Water Reacur. Res., Paper 300911

Water Reamer. Res., Paper 390971

3160 Remotf and streamflox 510CHASTIC STREAMFLOW MODELS FOR BYDROELECUL SIOU RANGET and streamflow
SIOURASTIC STREAMFLOW MODELS FOR BYDROTICES
SYSTEMS
H.Y.F. Parkire, G.C. Olivhire, E.E.S. Cata of
J. Kelman (Systems Department, 1924 - firth
de Pesqelsss de Energie Eletrica, P.O. to. 1781
20001 - Rio de Janeiro, Brazil
Inis paper describes the developent of
monthly streamflow model for the Emillin
hydroelectric system. The model is bated on to
disaggregation of lag-1 actoragrassive tough
flows into monthly values. Model failure
include eddition of new niber, amplementation
generation of monthly (laws and serration of
negativo values. A methodology for altern
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TONOMIC EVALUATION OF MAIR MARYESTING IN MICH-CATCHMENTS
C. Oron (Ben-Gurion University of the Beger, Juste Claustate institute for Oeserl Recerch, Kirgat Market Colors, Jacob Colors, Jacob Colors, Little Market Colors,

tip) General (Small Reservoirs)
Ol'Thium Design Of Small Reservoirs (TANK)
O. 1. ficting (Department of Civil Engineering Intervior)
Califarmic, Davis, California, 95616). P. N. Sauma
Small reservoirs, nailed lanks, are a part of useful
and many other countries. Though considerable invested
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is heing planned to construct more of them, so invested
is held to be a discover the most nillelent design of the
itahis. This paper proposes a nonlinear optimization and
its design them tables. It is, in a sense, supported
includingly because a traditional approach it combined in
intensive or high technology construction methods. Engine
watersupply, optimization, tanks,
Water Seasur, Rea., Paper 190693

### Meteorology

3715 Chemical composition and chemical Interactions on THE TEMPORAM INCREASE OF TROPOSPERIC CM.
O.W. Etheli (insitual Fur Aumospherische Chemic, 1978).
Consciences and the forest of th J. Geophya, Res., Orean, Paper 303339.

J. Geophya, Res., Orean, Paper D0339.

3715 Chemicay composition and chamical interactions ON THE VARIABILITY OF ATMOSPHERIO CARRON Official CONCENTRATION AT BARRON, ALASEA DURING NUMBER.

E. Haltar (Cooperative functive for Eusearch in Environmental Science, Campus Son Add, Selvative of Educative or Surgery, Alasea and spile surtains CDs commentation of Surgery, Alasea and spile surtains CDs commentation of Surgery, Alasea and spile surtains CDs attained behivsen CD, cooperative all mass. The targest positive assaulies of Concentration by seasing the talenton executed atth reintively deep surface-bed kratico excurred atth reintively deep surface-bed kratico excurred atth reintively deep surface-bed kratico excurred at haseas I qualitatively consultation of these air haseas I aquitatively consultation of these air haseas I aquitatively consultation of the assault CO environ, such as a thy interaction of these air haseas I aparticular that the proposed for the intitudes in a semmer sheller to that perposed for the intitudes in a semmer sheller to that proposed for the intitudes and the contributes august that the satisface and security and the security of the contributes a station of the surface through the contributes a station of the surface through the contributes and the contributes a station of the satisface and the satisface through the contributes of the contributes and the satisface and

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I. Seephys, Ise., Green, Paper 5:00339

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HER SUSSEDENT LIGHTHNES SERIEMS STROKES
L. Lockes (Department of Electrics) Sugmenting,
Cheretty of Vierids, Catmacvific, FL 3661, N.A.

plantify of Plantide, Gainacellia, Th. 1861; N.A. Institute tight intensity has been measured photographically as a function of intights and time for policially as a function of intights and time for even rubequent return strokes in two lightning liables are ranges of 7.8 and 8.7 km. The tlim measure foods 147a Sholiberst which has a roughly consist Special response havesan 150 ms and 670 mm. In the resolution was about t.0 peac, and the pullal resolution was about t.0 peac, and the pullal resolution was about t.0 peac, and the pullal resolution was about the make followed by a flower decrease to a reset rise to peak followed by a flower decrease to a velectively constant value. The modified of the initial it into peac decreases exponentially with height with a decrey constant of about 6.5 to 0.6 km. The 20 to 60 percent rise time of the hitial light algual is between f and 4 peac hase by the time the return stroke reaches she aloud bess, a hight between t and 2 km. The light fritensity 30 peace first the initial peak are latitudy constant with hight and has an ampfitude that is 11 to 30 percent of the initial peak are latitudy constant with hight and has an ampfitude that is 11 to 30 percent of the initial peak at aloud hase. In logarithm of the peak light friscoity near the proof is roughly propocitions in the initial peak is cloud hase. The second of the initial peak at the puries decrease with height may be much lower than the light decreases. The absolute light second returned decrease with height may be much lower than the light decreases. The absolute light intensity has been confined at the following themsel segments to similate the reliberated att-sky photoslectric decrease for on and Krider (1962). Using this onched, we find that the man peak cadience user the ground is 6, f x 10 year, with a test renge from 1.4 a 10 to

L Stophys. Ro., Oresn. Paper 300602

199 General (Atmospheric measurements)
104 ATMOSPHERIS LIFETIME EXPERIMENT, 19: RESULIS FOR
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104 AL furnald (School of Geophysical Scienses, Georgia
104 Attmiss, 19: Rechnology, Allenia, Georgia and CAP,
104 Norporated, Atlanta, Georgia), R. G. Prinn, P. A.
107210 A. Stemmode, Y. R. Alyee, C. A. Cardelinn,
108 A.L. Crawford
108 Assurements of the atmospheric concentrations of
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### Oceanography

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Wile Chankel Oceanography (Calklum Carbonate)
CHNICAL ACCUSTATION VARIATIONS INVESTINE PROF CUSTEMT
WINDO THE PROF. 110, 300 YEARS
S.A. Boyls (Department of Earth and Planetery Softmass,
Bistachuseuts Institute of Tachnelogy, Cambridge,
S.A. Ulis)

Established Institute of Technology, Cambridge.

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The titrolum to aliminum retim in more Vi9-10 is titrolated to clus insatilects accumulation reton. This titrolated to clus insatilects accumulation according to the property of the control of the contro for is due to extonee a productivity decreases in the forth Allentic, 25% may be due to a disciplination; the forth Allentic, 25% may be due to a disciplination; talliquest extonets attack, and the venidum! 50% mix be due to a tough productivity increase. These stignants are consistent with observations of Cauliorities accordance with the beauty allentic to the consistent with the tended and accordance to the North Arlentin. With the tended and accordance to the North Arlenting that the conditions and the production near the record of Wallentin and the production near the record of Wallentin and the production that the record of Wallentin and the production that the production is a present that with the tack which are the productions are the productions and the production that the production is the production of the production that the production is a production to the production of the production o by the difference of the quarte deposition near tic record, for 10 detail the record differe self-testicity from the organ fattops record, and may produce difference of the deposition of the deposition of the deposition of the meture of nimete.

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1. Geoglys. Res., Greeo, Paper 301005

4765 Euriace Mayon
'LAYOVZe' in Entrilitz RADAF LYAGES OF OCEAN WAVES
at LR. Cower, linetitute of Otean Sciences,
p.O. Box 6000, Sidny, B.C., Conada, VEL ADZ;
Present models explaining radar imaging of ocean
surface waves have coosedered variations in radar
cross section of the titled or roughesed surface, and
valocity Bunching effects caused by the depplar shifts
of moving scatterers, it is pointed out here that
simple 'layovar' effects will sause an additional,
elequificant modulation by the Lange Orightness the
increases the visibility of range-traveling waves,
[Sanote sensing, rudar, surface wewart.] J. Geophya. Ros., Gremm, Paper 100981

A780 Underwater Sound
ON THE REMOTE ACOUSTIC DETECTION OF SUSPENDED SEDIMENT
IN LONG MAYLELANGING
hims S. Hay (Department of Physics and Envicondised
finesticute of Cold Ocean Science, Hamot is! University of
Soufcandiand, St. John's, Seaf-quadiand AlS IXII
Experiments results are presented which indicate a
Linear relation because the time-everaged amplitude of
the snowlope of the backscettered acoustic pulse at
192 hBx and the square toot of auspended sediment contentraction in the 10 to 10 mg t1 range. Particle sizes
tagged from to 160 hm. The measurements rate made in
a negetively buoyant, when tailing dischates plums in a
submarine channel at depths of 60 to 90 to 18 Report inlet, S. C. From the theory of ensuestic beaheastist from
a solid elastic aphere in the hayleigh region it is
shown that if the pressure amplitude of the beckscatresuld wave is kayleigh distribeted, then such a linear
relation to to be aspected. Expressions for the optimus
scountic feaquency far the detaction of diute suspensions at a given range and for the minimus detectable
concentration are obtained assuming a thermal naise bestground. The possibility shat bubbles contribute to the
backscatter is considered and found to be salikely on
the basis of probable bubble titalines.
J. Geophys. Res., Greso, faper 169910

1799 Comoral (Bubble Persistence)
THE PERSISTENCE OF AIR SURBLES AT A SEMMATER SURFACE
Scott R. Burger ead Dungan C. Bimschard (Atmospheric
Sciences Research Center, State University of Haw York
at Albany, Albany, NT 12222]
The Line an air bubble presists at a sessuler
surface is a function of many factors, including the
relative hunddity and speed of the air over the surface
of the unior. We find that bubble surface life
leoresses is magnitude with decreasing bushdity and
increases is magnitude with decreasing bushdity and
increases is magnitude thing the bubble surface
by a mallotty gradient along the bubble sup. This produces a surface ionsion gradient (Marangoni effect)
that increases bubble surface life.
J. Geophys. Res., Paper 10933

### Particles and Fields— Interplanetary Space

S310 General (Cutoff Rigidity Veriations)
THE EFFELT OF LOCAL PERIURBATIONS OF THE GEOMAGNETIS
FIELD ON COSMIC RAI CUTOFF RIGIDITIES HI JUNGFRAUJOCO

SHE EFFELT OF LOCAL PERIMENTIONS OF THE SECHARIELIS (10 ON COSMIC RAI DUIOFF RIGIDITIES HI JUNGFRAUJOCH AND LIEL.

F.O., Filletiger, O.f. Smart and M.A. Shas (Air Force Gaophysics Laboratory, Sanscoa AFS, MA D1731)

He have innestigated the effect of incat perturbations of the generalized the effect of incat perturbations at the generalized on the vertical cottoff rigidities and their changes were determined by utilizing the traditions and their changes were determined by utilizing the tradeled as a simple dipole field to which the disturbance field it superposed. It was found that the cosmic ray cutoff rigidities are nost centitive to vertaining of the z-corponent of the geomegastic field at geomegastic latitudes -20°C A v 30° and at longitudes within 90° to the eatt of these morthern hemisphere stations. Furthermore, cutoff rigidity vertains at liel ere predominantly due to changes of the geomegastic latitudes -20°C A v 30° and at longitudes within 10°C v C 4.5°m.

For both locations the dependence of the main, effective, and storner vertical cutoff rigidities on the results and storner vertical cutoff rigidities on the radial, latitudinal and langitudinal structure of the massic parturbations the rigidity. The results are discussed with respect to the theory by frainsn (1953) describing the effect of a ring current on casmic ray cutoff rigidities. It is sise shoom that for the ansiyels of the characteristic properties of the correlation between cutoff rigidity vertaition and epocific generalization between cutoff rigidity vertaition and epocific generalization securements are brigidity corresponding to the life of surface of the correlation between cutoff rigidity useful perspecter. (Cosmic rays, cutoff rigidities, magnetic storms).

J. Geophys. Res., Olus, faper 3A0919

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### Particles and Fields-Ionosphere

5530 High-iettlude fonespherie currents
EQUIVALENT LONGSPHESEC CURRENT SYSTEMS REFRESENTING
LUMAR BALLY VARIATIONS OF THE FOLAS ORDMANNETIC FURILD
S. Kersuebits (Sigh Altitude Observatory, NCAR, Soulder,
Colorede 50107) and E.-V. Nu
Equivalent longspheric current systems of the lanst
daily geomagnetic variations at both high and mid-los
incitedes during a solar estire paried are estimated
from geomagnetic data for these sessions and the yearly
sverage. Clast convective currents as high latitodes
are found in addition to the well-hoose mid-lon tartitude
turrent systems. Finid-signed elactric currents as rail
as the wind dynamo effects which produce the obtained
aisetrin current systems for the samidioresi variation
are arealmed. It is conclode that the wind dynamo
plays a basic role is producing the current systems at
high latitudes, since inner affects on the fieldaligned current distribution are difficult to explain.
(Current systems, field-signed electric currents, whed
dynamo effects).
J. Osophys. Res., Otms, Paper 3A090A J. Oanphys, Rea., Otms, Paper 3A090A

J. Camphys. Res., Otms. Paper 14090A

5530 High-Intitude Josepharic muricula
SPATIAL BELATIONSHIP OF FIELD-ALIGHEN CURRENTS,
ELECTROS PRECIPITATION, AED PLASHA CONVECTION IN
HIR AMERRAL OWA.

8. P. Cotsy (Center for Sps. Soi., Physics Frag.,
thiv. of Testes at Dalies, Stchardson, TX 750801

A tachnique has been developed that ellows the
annalysis of magnatometer data from Atmosphera Emplorart-Guring those periods when the spacecraft le
spisning and ecilpsed (nor smatic). The attilication
of these magnatometer searcements to detaralos tisidsligued current siructure for comjunction with emergetic
partiful and plasma toownetion messaresmis from Ax-C
cebles on to dearmics relationships between these
phenomena in the nightime surgest seatures present
1800-2200 MLY and 0100-0600 MLT it is observed that,
in general, the regions of acceptate slatten pecolpfrattom (7) km2) apan both Segion t and Region 2 currents with the poleward boundary of the Region 2 currents with the poleward boundary of the Region 1 currents approximately nointident with the poleward
kilovotc elenters boundary. Simultansous observations
of plasma townentoes indicate that the reversal fros
as meard to antisumward convention is aim is georal
collocated he within h degace of towardant latitude
to the poleward fluid-nligued current boundary to both
the avening and moreing sactors. Tr is seen that the
low unbookluly in the winker poster the leptine the
absence of flaid-sligond corrents in that the
doca indicate that the Segion 1 turrents in the tata
avening and acity morning sectors if a fix cloud flaid
ivens satesding aerthested tron the laser adja of the
magnatomyberite boundary 1, part (Currente, convention,
particles pracipitation).

J. Setophys. Res., Olas, Paper 140945

lew condoctivity in the winter poter the leptine the absence of field-elligend cortents in that region. The dock lodicate that the Segion I turents in the late avening and early sorting sectors if an closed (field lives satesding serthers from the isser edge of the magnatospheric boundery layer. (Chrysnic, convection, and investigation) particle principle and comparations.

J. Geophys. Res., Olus. Paper 180945

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Parametria scupiling processes of later and comparations convention.

J. J. Bojhs. (Center in Atmospheria and Space Sciences, J. J. Bojhs. (Center in Atmospheria and Space Sciences, J. J. Bojhs. (Center in Atmospheria and Space Sciences, J. J. Bojhs. (Center in Atmospheria and Space Sciences, J. J. Bojhs. (Center in Atmospheria and Space Sciences, J. J. Bojhs. (Center in Atmospheria and Space Sciences, J. J. Bojhs. (Center in Atmospheria and Space Sciences, J. J. Bojhs. (Center in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs. (Conter in Atmospheria and Space Sciences, J. J. Bojhs

dansity region, a nightside ridiatitude trough, and a region of slightly enhanced densities in the autoral zone. Airhough the davide high donsity region was due to solet EUF radiation, it was not symmetrical shout local noon (1000-1000 IT sector) ewing no the offect of bayinored transport. The nightside aid-lastitude wrough was the despear, the widert, and roached its toost equation and the torself the solet was able to reproduce these two fastures quite accurately. In the dual sector, the trough was littled in and fre latitudinal extent was restricted by a discrete ourret are, a fasture not included in the incomparts model. Except for this are region, the enhanced sloctron denstriae in the survail zone wore adoquality described by the arerage precipitation fluxes used in the model. The observed plasm drift velocities were consistent with a two-call, asymmetric convection pattern with enhanced flow in the duals sector. Outside the polar cap, the fail-off of the cognetospheric potaguist with instrude was proportional to the inverse of the clue of culatitude units fourth power. The congretion pattern explayed in the model included these features and had a 50 SV crosp-polar-cap potantial. Efforts to reproduce the observed behavior using a larger cross-polar-cap potantial (9Phv) of a symmetric pattern are also presented. These were generally less entreaful and demonstrate the sensitivity of the anriphology of the Fragion at high facilides to the convection process.

SAAI lonespheric disturbences
MODELENC OF SYACED-PECKIVER SCINTILIATION
SEASUBLEMENTE
A. W. Escalh (hepertment of Fischritz Engineering, Dhiversity of Tilinofe at Urbene-Chumpsign,
Urbana, Illinois, 61801), C. E. 11u and S. C. Teh
Spaced-receiver scintiliation resourcements are
modeled applying extalliation theory together
with model appetral teprementations of nonfrosen turbulent medis. The effects of velocity
distribution of scatterers, diffusion or irregulerities and valocity gradient across the
scattering layer on perameters derived from
spated-receiver scintiliation separisance are
studied. Soch correlation and dispersion
modeling are compared with observational data
from the squatorial region. It will be demonstrated byte self-consistent models can be constructed is interprating the data and information
about the drift volacity flaid in the lotemphere
ran be abtained from syntod-receiver experiments.
(Spaced-receiver, scintilistion)
Rad. Sci., Pepar 350861

5441 LONGOPHETIC DISEUTE-INCOME COORDINATED MEASUREMENTS OF COM-FRENCY ELECTRON PRECIPITATION AND SCINILLLATIONS/TFC IN THE

CORDINATED MEASUREMENTS OF TOW-FRENCY ELECTRON
PRECIPITATION AND SCINILLATIONS/TEC IN THE
AURORAT OVAL
Summade Sew (Ensemble College, Souten MA 02115),
Elisen MacKenzie, Santinay Saus, E.C. Carison,
O.A. Hardy, I.J. Sich, and E.C. Livingston
A case study of coordinated observations of lowenergy 1-500 off whether precipitation in the auroral
oval from ENSP/FZ and phase and amplitude scintifictions from Come Bay, mains a goostationary antuility
transmitting at 244 MHz, is presented. The procipitation event toof place during the capaciton phase of an
intense evening substorm, when the equatorizary boundary of the diffuse aurora reached 59° invariant latitiode. Particularly large phase scintilisations till
radiums for fluctuation frequencies - 0.0067 Hr) were
found to be well correlated with Intense Illuses (10°
particles (for a sur-1) of precipitated how-energy
electrons. Total electron content and outpretmeter
transurements indicate that the onset of the precipitation event was about 10 min prior to the 1657 plans.
Mighin this time scale, the tomization generated in the
f-region could reach the topoid no that the thornal
sensor on board the DMSP significate was able to because
a factor of 2-3 density enhancement at 800 km. The
locitudinal width of these density structures to consistent with that of f-region blobs observed at
Chataniba. The gradient scale-length examined in the
topside was only 30 km, which was probably responsible
for the last growth rate of the Beintillation ratio changed rather drastically compared to quite magnatic class, bouwer, implying that increased convection velocities during these magnetic disturbances were
precipitly responsible for the anhanced phase scintillaton as incline two. Particle (responsible) and consecution well of the particles of the anhanced phase acturillatenses of the scintillation of the anhanced phase scintillatenses of the scintillation of the anhanced phase scintillatenses of the scintillation of the anhanced phase scintillation.

5550 Airglow OFFENDEXCE OF AURORAL FUV EMISSIONS OF THE INCIDENT ELECTRON SPECTRUM AND NEUTRAL ATMOSYMERE 0.1. Strichland (Beers Associates, Ioc., Post Office Sox 1549, Reston, Oirginia 17090), J.R. Jaupersa and

Sox 1349, Reston, Cirginia 12090). J.R. Jaupersa and J.A. Whalen.
In this paper we execute the relationship among tetrafo prochent surroral RIV ministen factors, the incident electron spectrum, and the model satural strosphere. Olven the neutral strosphere we show that for simple models of the incident electron spectrum (Maxwellian and Generatan in energy estellite measurements of FUV emission features, in parintiple, determine the incident sisetron spectrum. We size discuss the relationship between the incident electron spectrum and the 8-region plasma density prairies for the continuous (diffuse) surrors and far a stable arc. (YUV emissions, surrors, slettron transport).
J. Geophys. Res., Sius, Paper 140170

J. Geophys. Eas., Sine, Paper Janifo

Since Indicate Statistical Convertible of Statistics of Countries Statistics and Statistics of Countries Statist J. Geophyh. Res., Blue, Paper 3AD921

### Particles and Fields— Magnetosphere

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THE DISTRIBUTION OF AUROHAT ELECTROSTATIC SHOCKS
BELOW 2000 KM ALLITUDE
8 1 Bennett Physics Department and Space Science Laboratory,
University of California, Berkeley, California, 94720), 35 Termenn, and P.

University of Chiffordia, Berkelay, Chifornia, 94720), M. Temeran, and F. S. Mozer

Thir paper examines the distributions and characterisates of electrostatic shocts as observed by the Sf.J polat-orbiding satellite. That is several oval coverage by the satellite at all magnetic focal times and at all shiudes between 240 and 3000 tm. Electrostate shocts are responsibly uniformly does based in magnetic local time, with a slight increase in the probability of occurrence in the cups region and a decrease in the population of the pop

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57() Magnetic stords MAGNETOSPEERIG PROCESSES PRECEDING THE OWERT BY AN ISOLATED SUBSTORM - A CASE STUDY OF TES MARCE (t, 1978 MAGNETOSPEERIC PROCESSES PRECEDING THE UNKERT OF AN ISOLATED SUSSTORM - A CASE STUDY OF THE NAMES IT, 1978 SUSSTORM - A CASE STUDY OF THE NAMES IT, 1978 SUSSTORM AS EISHIGH (Smeat Stage of Space and Astronausfeal Science, formabe, Megure, Tohyo 15f. Japan) and T. Isolade (SOAA/Space Mrviropment Laboratory, 325 Steadway, Soulder, Coformado, 8000f)
We examined to deseff the effant of a southward turbing of the Jynserplaneray reagencie field 1807) on the state of the ompactusphare, tables seventage of the availability of the date from INI magnetomater marklein theius and feom several spacescrift. A class onset sebstore obccurred on Merce ff, 1978, when the segmenters teatings were forcated in she middight to morelog seator and she appearanted was need the squasorial ptens of the nights side magnetosphare. The onset lose of the substorm copaniton phese could be determined ansmhigueusly in saves of both ground-hased magnetic sod survoral algoristme, and shere was an interval issuing about t hour between the INF southward turbing seat this onset. So isls inservaning interval issuing about t hour between the INF southward turbing seat this onset. So isls inservaning interval to distribute to the onset of the 100 spheric turtant is driven directly by the solate ruled-magnetaphace coupling. The onset of the espander phase was then the substorm energy was supplied by the release their the substorm energy was supplied by the release their the substorm energy was supplied by two components. Strattly oriem's additional and simple event is supplied by two components. Strattly oriem's additional and simple event is supplied by two components. Strattly oriem's additional and simple event is supplied by two components. Strattly oriem's additional and simple event is supplied by Locading-unloading', the relative uportence of which was as supplied.

I. weophys. Pes., Sive, Paper 140914 5755 Piesas Intiablitles 5170 Short-Period (Lest than 1 day) Ysristiant of Reg-SITU Short-reriod (Less Luda)
netle Fields
SATURN'S MAGNETO'SPERE: OBSERVATIONS OF IOM CICLOIDON
MAVES NEAR THE GIOWI L SEELL
E. J. Smith (Jat Propulsion Laboratary, 4800 Oak Grove
Driva, MS 169-506, Patadoma, California, 911091, 8. 1.

E. J. Smith (Jat Propulsion Laboratary, 4800 Gav Grove Driva, 85 169-506, Patadama, Cellionia, 911091, 8. 1. Yearutania presolution (0.75 sec) meturements obtained by the Ploncar II Yetter Belium Engentemeter included by the Ploncar II Yetter Belium Engentemeter included by the Ploncar iii Yetter Belium Engentemeter included present near the Global Eshell between 1 = 6.3 and 6.7. Although Glone was far from the spincernit, the waves were observed when Ploncar was both inbound to, and outbound from, periopsis end are presumably associated indirectly with Glona. The moves have nother extended indirectly with Glona. The moves have nother extended indirectly with Glona. The moves have nother extended in the following the Plonear II pleans sealing are detected a pack placed drop Dione's surface and tentativally desetfield at 0°. Subsequent Voysiger obtervations is this inner torus appear to be cansitteet wild 0°. The characteristic period of she waves is well belaw temportom gyroparlod. Belawas the heavy loss are hot (-10° 2), the Alfvan phase speed and the fon ihermsi speeds are nearly the term, ion systatron resenance of the waves with the dominant fon appears capable of generating the waves. Heavetical arguments beend on she greath retex at the term of but that or assonance involving 8° tons with energies of a few tay mannel be arcluded. The arithmeter of a plich angle entspropy accordiated with a loss come in implied, for 0°t, e plith angle asisotropy at 0.70, terrespecially 10 the 11ff = 1.7, ia predicted. Pitch angle extending 10 the heavy loss by the wavet thould take precipitation with the potable production of surrors near 57° istitude.

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3775 Trapped Particles
VYYAGER OSCIPLATIONS DY SATURNIAN 10N AND ELECTRON YSASS
BEACE OSSITIES
T. P. Armstroes (empertment of Physics and Astronomy,
University of Kansas, leutwees, Kansas 65045), M. Y.
Parnames, O. Y. Osli, Hi, and E. H. KrinfgSa
Voyagar 1 and 2 Low Esergy Charged Particle (LECP) observetions of 30 keV to 1 MeV atantron and fon senergy
spectra and sngular distributions have been used to
calculate phase spect densities as commant (frat and
second edebatis invariants in the Saturnian magnese—
apheve. The results has generally consistent within
the obtained alam indicate a source of lone (occased within
the obtain indicate a source of lone (occased within
the obtain indicate a source of lone (occased within
the obtain indicate a source of lone (occased within
the obtain indicate a source of lone (occased within
the obtain indicate a source of lone (occased within
the obtail distribution from an external source. The data
obtained alam indicate a source of lone (occased
10 to 40 MeV/Gauss ions as well as a source of efectroma
at about 3.5 Mg which produces particles at 100 to 200
MeV/Gauss. Higher magnetic moment (200-400 MeV/Gauss)
torm outsed from the summard during the summard
diffusion of the phase apass density suggests invard
diffusion at the region of decable trapping at 15 Rg the
boundary. The fdmxiffcation of sources of tow (10 to
200 MeV/Goneel magnetic moment particles dmap in the
Saturnira magnecaphere la a oew result of this work,
Eswecal smalyses of the observed phase space densities
is terms of time-Jandapsadant radial diffusion are pessmattad.
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5775 Trapped Parbfelns
ABSORPTION OF EXEMSTIC PROTORS BY SATURA'S RING O
James A. Van Allea (Physics and Astronomy Departments,
The University of Love, lovis City, love, 32242)

A restudy has been cade of Picomer 11 data on the
Sistribution of asorgatic protons E, > 60 MeV in
Saturn's incer sugnetoephers. An improved value of the
sation of the Crash source atrough B to the radial dirfusion coefficient 0 is 6.9 × 10<sup>-14</sup> cm<sup>-1</sup> et + ~ 2.67 %

(t B<sub>m</sub> = Saturn's equatorial radios = 60,000 km; layes
the vecently calculated lover limit os 5 by Slake et
als, one finds as upper limit os 5 by Slake et
als, one finds as upper limit os the sean residence
time 7 spainet diffusions is 5 × 10<sup>2</sup> a (13 years) in the
major peak of the distribution, whereas using or
mariler extracte of 0, one finds T ~ 8.2 × 10<sup>2</sup> a (7.0
years). To two corresponding Sebermisskines of 0 are

> 1.3 × 10<sup>-11</sup> and ~ 2.8 × 30<sup>2</sup> I (2 cm) - respectively.
A generous upper limit on 0 fs. 2 10<sup>-14</sup> R cl - respectively.
A generous upper limit on 0 fs. 2 10<sup>-14</sup> R cl - a
round Yron's tauthy of Yne slot region seasolated with the
co-whiting matallicat tryl 32 (1950 RS) and 1950 B1.
The mean lifetime 7 of energatic protons seasolated with the
voyagar date on negatio patical opecity n ~ 3 × 10<sup>-5</sup> and
or redisi sixth dr ~ 500 km, one finds that the partionishes in Ring 0 hase an effective motor R>
0.035 ch, an areal mass density a > 1.5 × 10<sup>-5</sup> and
of R (for seizmand spherical particulates of where the
symbol c > dainotes the mean value over the distribution. It is reasquelty cartain that there are no
antallited bearing radii of the order of a filomatar or
larger associated with Ring Q and that uniques having
radii > 10 de contribute less than 10<sup>-2</sup> of the openity of a 10<sup></sup> J. Geophys. Rps., Blue, Paper 3A0907